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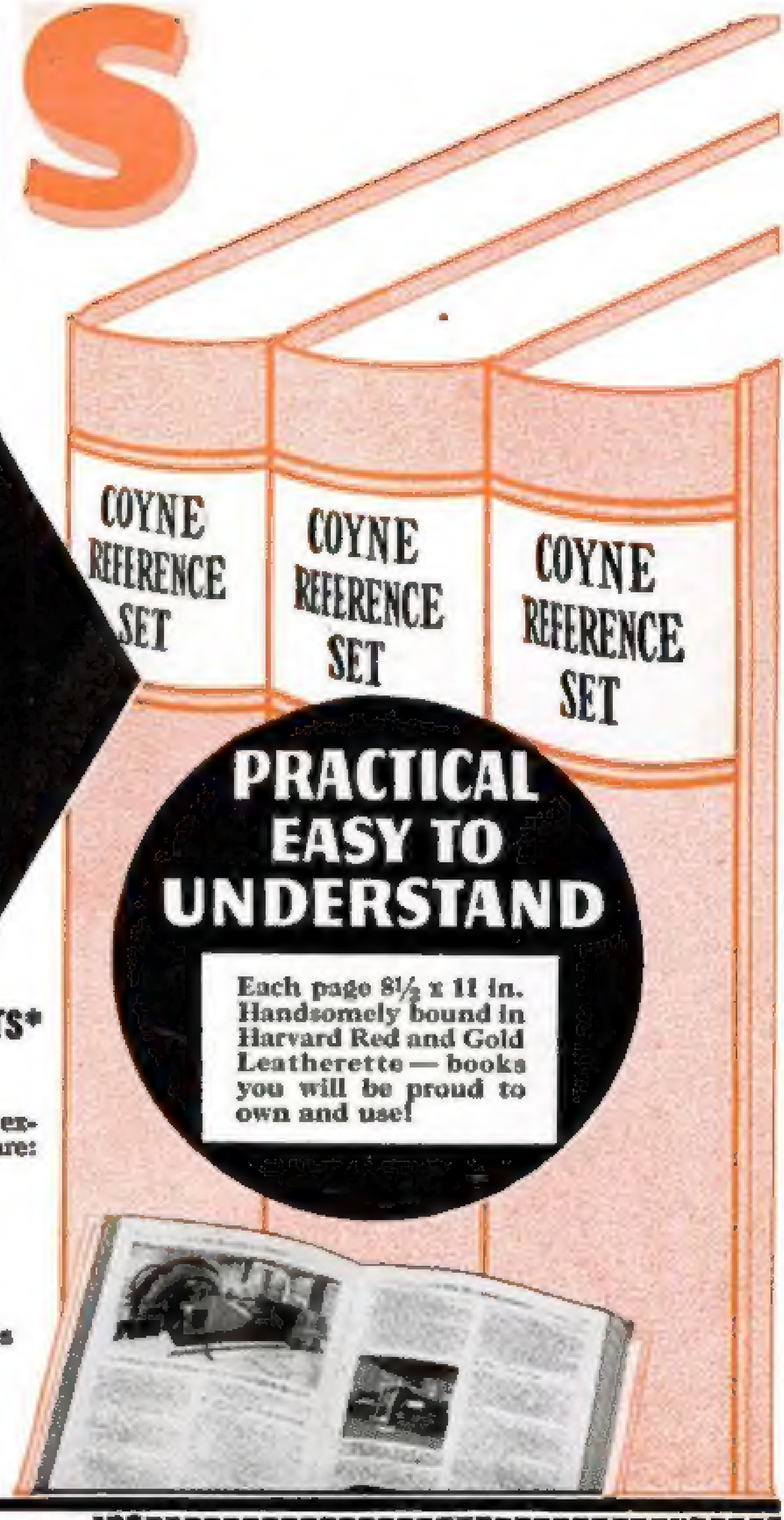

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POPULAR SCIENCE

FOUNDED 1872 MONTHLY VOL. 141 NO. 6

Mechanics & Handicraft

A TECHNICAL JOURNAL OF SCIENCE AND INDUSTRY

CONTENTS *for* DECEMBER, 1942

News

Automobiles

Home and Workshop

Departments

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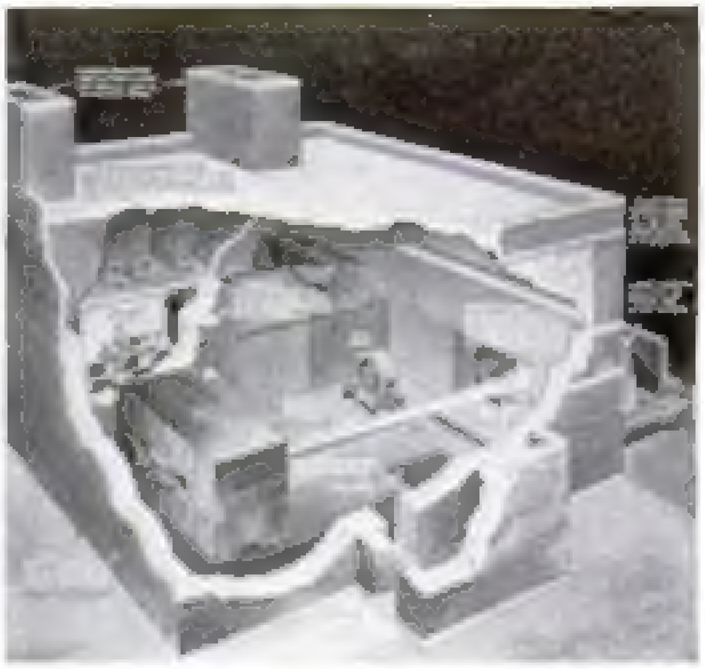


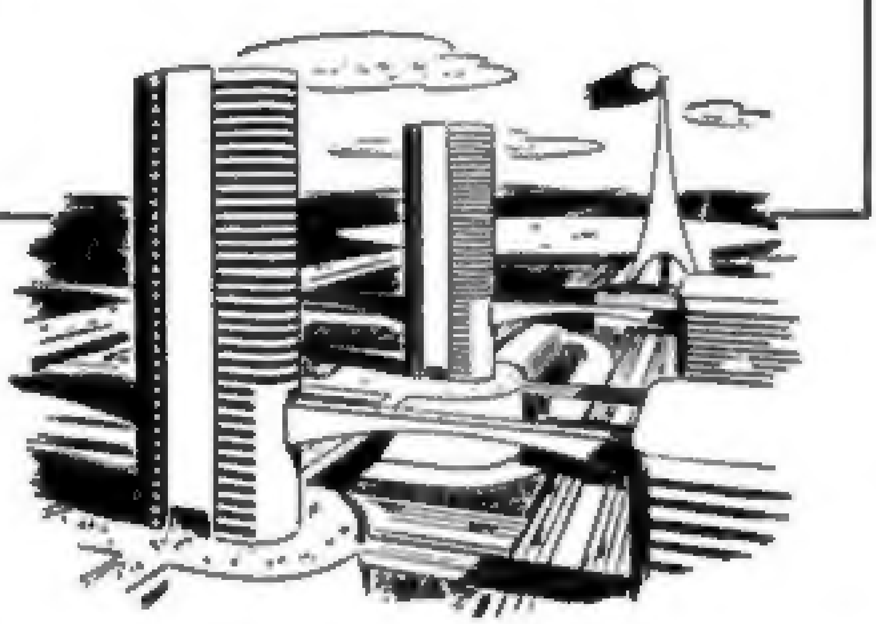
100,000,000 VOLTS is the new high-water mark in X-ray machines, reached in the huge "induction electron accelerator" now being assembled in the laboratories of the General Electric Company. Because of its devastating power, it must be housed in a specially constructed building, and elaborate precautions must be taken to safeguard its users. Its first job will be to probe thick slabs of armor plate and other metal parts of war machines. A story on page 58 tells how this giant will be caged by science and made to serve in war and peace.

Published monthly at 353 Fourth Avenue, New York, N. Y., by Popular Science Publishing Co., Inc. Godfrey Hammond, President and Treasurer; R. C. Wilson, Raymond J. Brown, Vice-Presidents; F. W. Briggs, Secretary. Entered as second-class matter Dec. 28, 1918, at the Post Office at New York under the act of March 3, 1879; additional entry as second-class matter at Dayton, Ohio. Entered as second-class matter at the Post Office Department, Canada. Printed in U.S.A.

Yearly subscriptions to United States and its possessions, $2.00; Canada, $2.50; foreign countries, excepting Canada, $3.00. Subscribers must notify us of change of address four weeks in advance of the next publication date. Be sure to give both old and new address.

Yes, things may be a lot different—

BUT!



UNDOUBTEDLY, the *post-war* world will be a *different* world in many ways.

Nobody can foretell just what things will be changed after the Axis is smashed.

BUT—

One thing, we all know for certain, will be the same as always! And that's the fact that the most important, best paying jobs will be held by TRAINED MEN!

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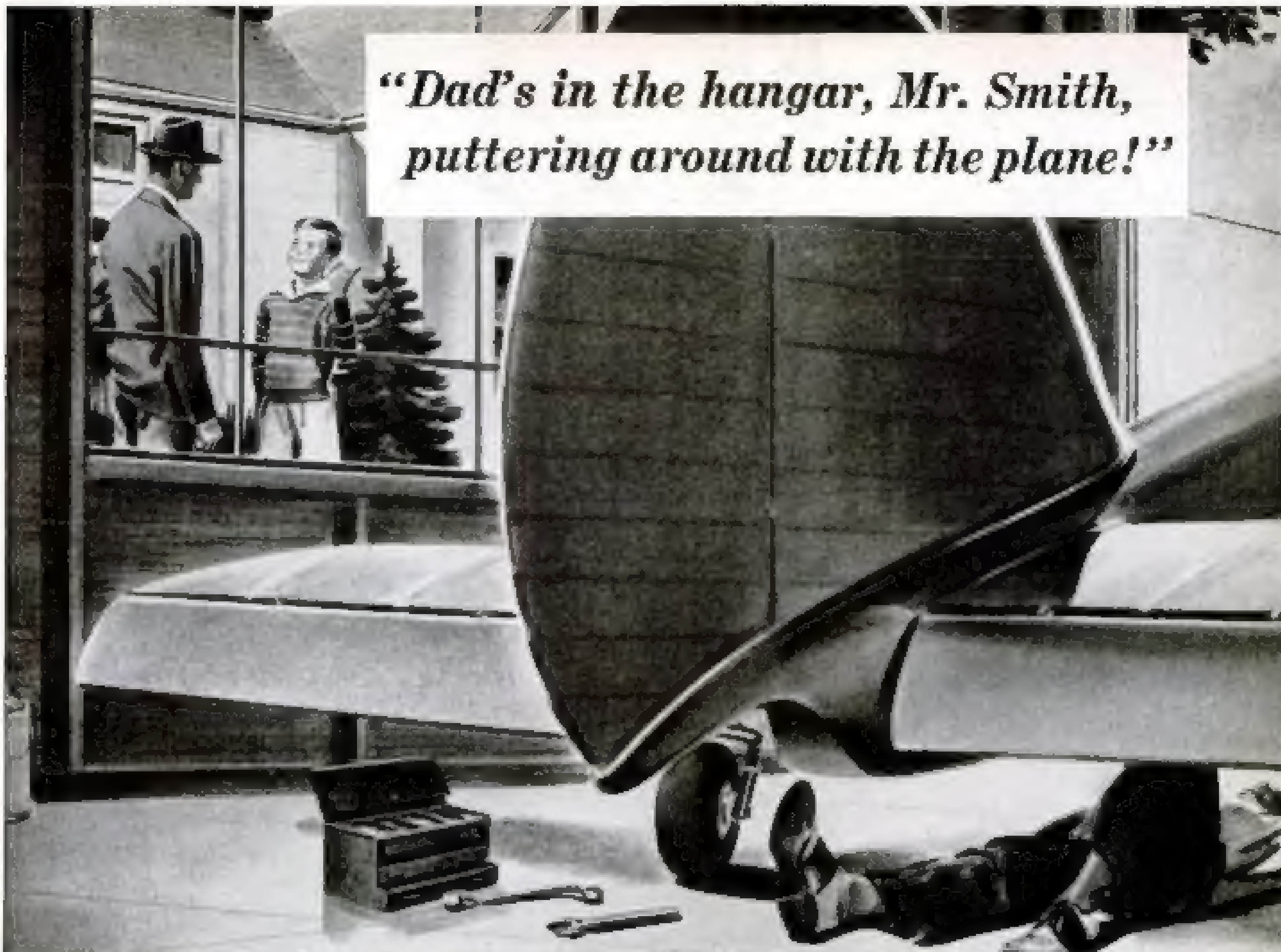

AMERICANS love to putter with things mechanical. It's this restless, inquisitive trait in our national character that has set the pace for the world of the present . . . that will build the new America.

Because we can already see it on the horizon. We can see it in the skill and ingenuity of the men now working night and day in the arsenals of democracy. These are the hearts and hands that will shape it.

These men, who are now making the world's best combat and training planes, will be making family planes for you and me and the folks who live next door. These men, now building bombing planes that are the envy of a warring world, will be making luxury transports and super-cargo carriers of the air.

How far off is the birthday of this new America? Not very . . . because our hearths and furnaces and production lines are already forging Victory.

You'd feel as confident as we if you were in B. F. Goodrich plants now . . . if you had seen what our Aeronautical Division has developed in the short span of a single man's life. Giant tires that bring a Flying Fortress to rest as gently as a tiny sparrow. Brakes that halt a ship that flies faster than sound can travel. De-Icers that defy the elements.

Today, this B. F. Goodrich equipment goes to the air forces of the United Nations. It flies with planes that make history over Wake Island, Burma, Tokio, and the Sahara. But *tomorrow* it's going to help make a different kind of history. *It's going to help America create the new world!* The B. F. Goodrich Company, Aeronautical Division, Akron, O.

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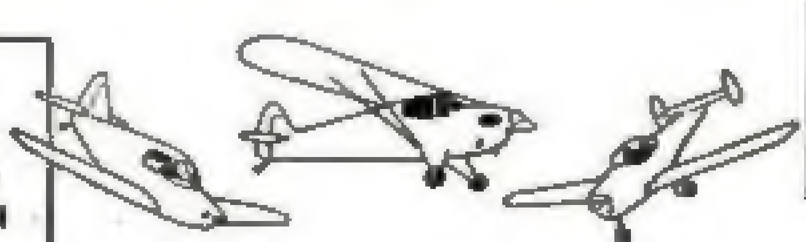

CULVER PIPER ERCOUPE

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AUTO-LITE SPARK PLUGS
IGNITION ENGINEERED

"SHET 'ER OFF WHILST THEY IS FIXIN' THAT BLOW-OUT, LUKE . . . AIN'T YOU HEERD THAT OIL IS AMMUNITION ?"

"PLUG-CHEK" INSPECTION SERVICE HELPS STOP GAS WASTE

Jake's got the right idea. Today everybody's out to stop waste of vital materials. Here's a tip. Ask your service man for a "Plug-Chek," the inspection service that helps him spot gas and power wasting spark plugs, aids in restoring gasoline and oil economy. Often simply cleaning and regapping your present plugs puts an end to costly waste. Ask for a "Plug-Chek" today.

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Contents (CONTINUED)

New Shop Ideas

Radio

Shop Data

The Handy Man

Woodworking

Coming Next Month

AUTOMATIC WEAPONS have made history in recent months, and will make history again. How well is America equipped with these arbiters of modern warfare? An article describes all the fast-shooters used by our Army and reviews the history of their development—including an early "secret weapon" that shot round holes in Christians and square ones in Turks.

HOW GOOD ARE OUR PLANES? You hear conflicting answers to this vital question of the war. What is the truth? An aviation authority applies a practical yardstick to our military aircraft, appraising their actual performance and comparing them with the planes of our allies and our enemies. His verdict is well worth careful study.

WALLBOARD, once considered a flimsy material suitable only for temporary building, has now grown to more durable stature. Fire-resistant, noise-absorbing, adding additional insulation to heat and cold, and finished to simulate fine wood paneling for the living room, or tile for the bath—here is a preview of the inexpensive but handsome home of the future.

SYNTHETIC JEWELS, from which jewel bearings are cut, are the latest triumph of American industrial inventiveness. Formerly imported from Europe, and vital to precision instruments in planes and ships, these bearings are now produced here in ample quantity. Illustrated with numerous photographs, here is the story of the synthetic gems which are so precious to our war effort.

FIXED GAUGES are the new "foolproof" measuring instruments now being widely used in place of adjustable micrometers. Because they are locked to specific dimensions, they permit only the most minute tolerance in the vital parts that go into tanks and guns. Learn how these new gauges are helping to make ours a high-speed, precision-made war.

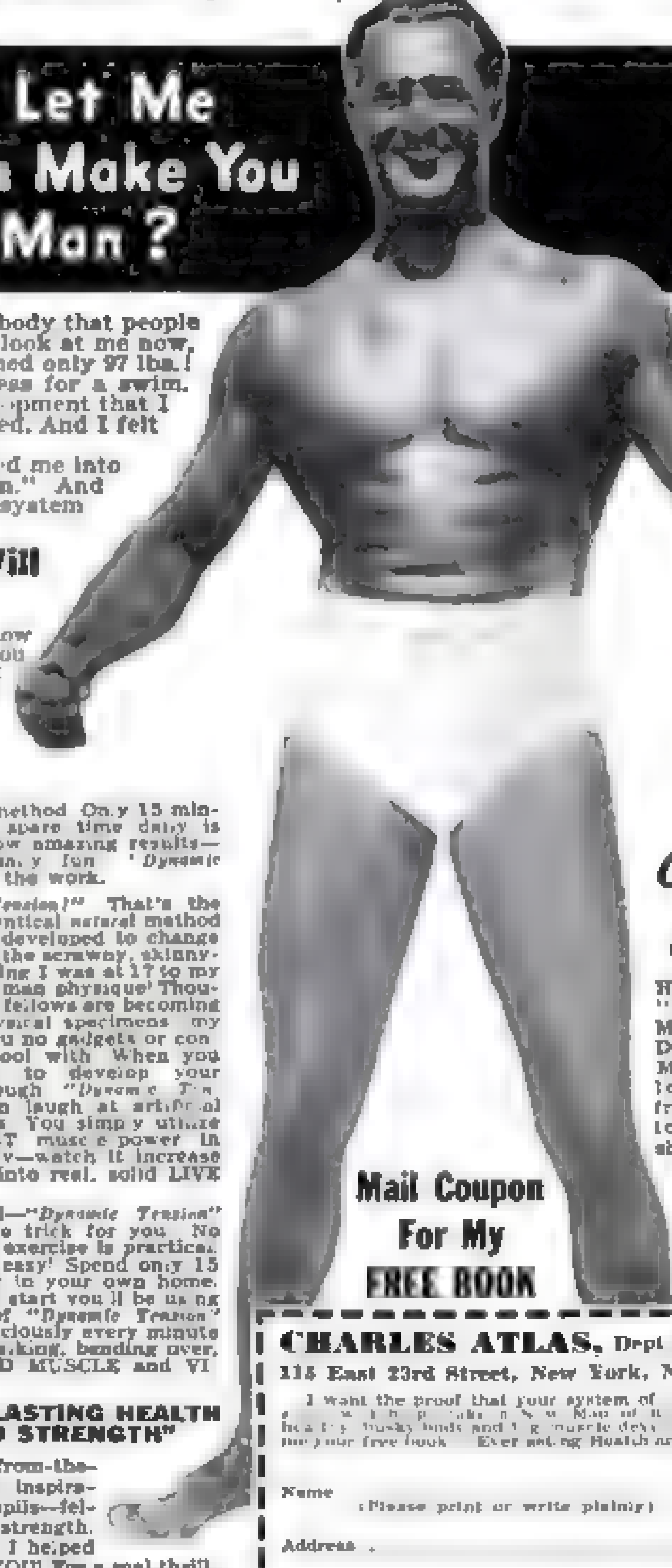
NIGHT VISION, long one of the stubborn problems of aviation, has now been solved by the Navy's new "Dark-Adaptation" method. Red-colored bulbs, red-lensed goggles and specially colored maps are what do the trick. Read this interesting article on how flyers, suddenly called to night duty, now take off with eyes that see in the dark.

How to Make YOUR Body Bring You FAME

...Instead of SHAME!

ARE YOU *Skinny? Weak? Flabby?*

Will You Let Me Prove I Can Make You a New Man?



I KNOW what it means to have the kind of body that people pity! Of course, you wouldn't know it to look at me now, but I was once a skinny weakling who weighed only 97 lbs.! I was ashamed to strip for sports or undress for a swim. I was such a poor specimen of physical development that I was constantly self-conscious and embarrassed. And I felt only HALF-ALIVE.

But later I discovered the secret that turned me into "The World's Most Perfectly Developed Man." And now I'd like to prove to you that the same system can make a NEW MAN of YOU!

What Dynamic Tension Will Do For You

I don't care how old or young you are or how ashamed of your present physical condition you may be. If you can simply raise your arm and flex it I can add SOLID MUSCLE to your biceps—yes on each arm—in double-quick time! Only 15 minutes a day—right in your own home—is all the time I ask of you! And there's no cost if I fail.

I can broaden your shoulders, strengthen your back, develop your whole muscular system INSIDE and OUTSIDE! I can add inches to your chest, give you a vise-like grip, make those legs of yours lithe and powerful. I can shoot new strength into your old backbone, exercise those inner organs, help you cram your body so full of pep, vigor and red-blooded vitality that you won't feel there's even "standing room" left for weakness and that lazy feeling! Before I get through with you I'll have your whole frame "measured" to a nice new, beautiful suit of muscle!

Only 15 Minutes A Day

No "ifs," "ands" or "maybes." Just tell me where you want handsome, powerful muscles. Are you fat and flabby? Or skinny and gawky? Are you short-winded, pepless? Do you hold back and let others walk off with the prettiest girls, best jobs, etc.? Then write for details about "*Dynamic Tension*" and learn how I can make you a healthy, confident, powerful HE-MAN.

"*Dynamic Tension*" is an entirely NATURAL method. Only 15 minutes of your spare time daily is enough to show amazing results—and it's actually fun. "*Dynamic Tension*" does the work.

"*Dynamic Tension!*" That's the ticket! The identical *natural* method that I myself developed to change my body from the scrawny, skinny-chested weakling I was at 17 to my present super-man physique! Thousands of other fellows are becoming marvelous physical specimens—my way. I give you no gadgets or contraptions to fool with. When you have learned to develop your strength through "*Dynamic Tension*" you can laugh at artificial muscle makers. You simply utilize the DORMANT muscle power in your own body—watch it increase and multiply into real, solid LIVE MUSCLE.

My method—"*Dynamic Tension*"—will turn the trick for you. No theory—every exercise is practical. And man, so easy! Spend only 15 minutes a day in your own home. From the very start you'll be using my method of "*Dynamic Tension*" almost unconsciously every minute of the day—walking, bending over, etc.—to BUILD MUSCLE and VITALITY.

Charles Atlas

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Readers Say:

Hot and Cold Running Water —at the Wrong Faucets

TONIGHT I ran across a puzzler that appealed to me as being just the thing to make the little man in 'Our Readers Say' tear his hair out. At a friend's house, I went to get a drink of cold water. After running the water for a few minutes, instead of getting colder, it became lukewarm, and stayed that way. Then I found that if the hot water tap was turned on, the cold water instantly ran cold; shut the hot water off again, and the cold ran warm. My friend's house is equipped with a standard electrically heated range boiler, and the water pipes are half-inch copper of the type called 'Streamline,' fitted together with soldered fittings. The taps I mention are about 20 feet from the water heater, at the kitchen sink. The inclosed sketch will show more clearly how the pipes run. The explanation, which eludes me, may help some of my fellow readers to avoid a similar unhappy situation should they undertake to construct a water system in their own home. It appears that my friend has had quite a lot of trouble with a lack of hot water on wash days, and we decided that the condition outlined is no doubt the cause of this embarrassment as well as a waster of power. The only way I can imagine this can happen is that the soldered 'tee' marked "A" in the sketch is acting as a siphon, drawing water out of the tank and mixing it with the cold water. However, if that is so, how is water getting into the tank to replace that which is drawn out, and cool the hot water, unless it goes down the little curved inlet pipe marked "B"? If this is so, then there is a flow of cold water down the inlet pipe, and a flow of hot water up the same pipe, which don't make sense in my language. Well that's it folks, let's see what the little man can do with that one. Incidentally, my friend has just finished making a beautiful job of construction on the sailboat *Whitecap,* the plans for which were given in last summer's group of boat plans. Believe me, she is a real man's boat.—N. M. R., Island Falls, Sask., Canada.

A Home-Workshop Fan Speaks His Mind

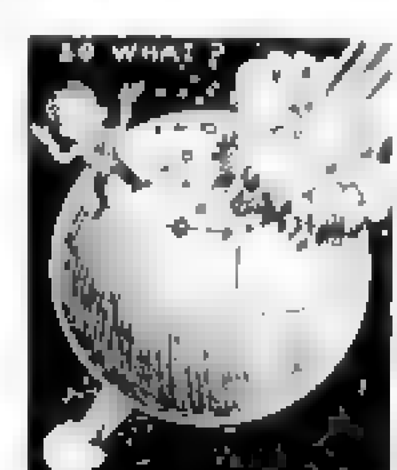
I THINK your present style and contents are tops in magazines of this type and I am specially pleased with your Home Workshop Section which has been so greatly stepped up. C. W. Woodson's metalworking projects are especially worth-while to me.—G. N. H., Milwaukee, Wis.

And Many a Dachshund Has Met His End That Way

IN A recent Un-Natural History, Gus Mager makes the statement that the reason why dogs turn around several times before lying down is to make sure they have their noses pointed upwind. This is supposed to be inherited from wild members of the dog family. Mager may be partially right, but the main reason is to let the dog smooth down his bed as he gradually lowers himself. He turns to keep the grass or bits of rubble from sticking into his hide as they would if he just flopped. This was told me some years ago by an 86-year-old Indian squaw who really knows her wildlife. May I also say I have been reading your magazine for a number of years and enjoy it very much.—M. S., Zurich, Ont., Canada.

Nobody'll Notice It If It Hits Us Now

IT IS known or expected that an extra-large meteor or planetoid on its way to cross the orbit of the earth in the near future. This one is supposed to be larger than the ones that made large craters in Arizona and Siberia. It is expected to hit the earth with such violent force that our planet will be pushed slightly out of its orbit and closer to the sun. Not only will it cause great destruction where it hits, but it will change the climate of the whole earth. Do any of your readers know any further details about it?—C. H. F. C., Jacksonville, Fla.



How to turn a hull into a hornet's nest

THE EFFICIENCY of an aircraft carrier depends upon power—steam power to propel it, electric power to operate it.

Powering these sea-going airfields is a typically *Westinghouse* kind of wartime job. It is a job that calls for the thousand and one different skills in things electrical that are second nature to Westinghouse.

Here is just a small part of the equipment that Westinghouse has designed and built especially to make American carriers outstanding engines of destruction:

★ Steam turbines, compact in size, yet so powerful they drive our new carriers *faster* than any enemy carrier afloat.

★ Elevators big enough to hold a bomber, fast enough to deliver a plane to the deck with minimum delay.

★ Generators on each ship capable of producing enough electric power to light a city the size of Seattle.

★ Intricate radio equipment specially designed to stand up under the shock of battle.

Westinghouse "know how" is being applied—not only to aircraft carriers—but to nearly every type of ship in our Navy.

In this, as in all phases of Westinghouse wartime activity, the long-range work of our Research and Engineering Laboratories has played a significant part. Discoveries in many fields are now bearing fruit in the production of better and more powerful weapons of war.

Many of these discoveries, we believe, will someday help to make a better peacetime world.

Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa. Plants in 25 cities; offices everywhere.

This advertisement has been reviewed by Government authorities and contains no information of military value to the enemy.

Westinghouse

... making Electricity work for Victory

Readers Say:

His Ambition Is to Be as Good as Gus Wilson

I have been reading your stories about Gus Wilson every month and I must say I really enjoy them very much. He is a great man and really knows his cars. I myself hope to be as good a man as he is some day. I love cars and love to work on them. I like your stories so much I just had to write and tell you. Give my best regards to Gus—G. G., St. Johns, Newfoundland.

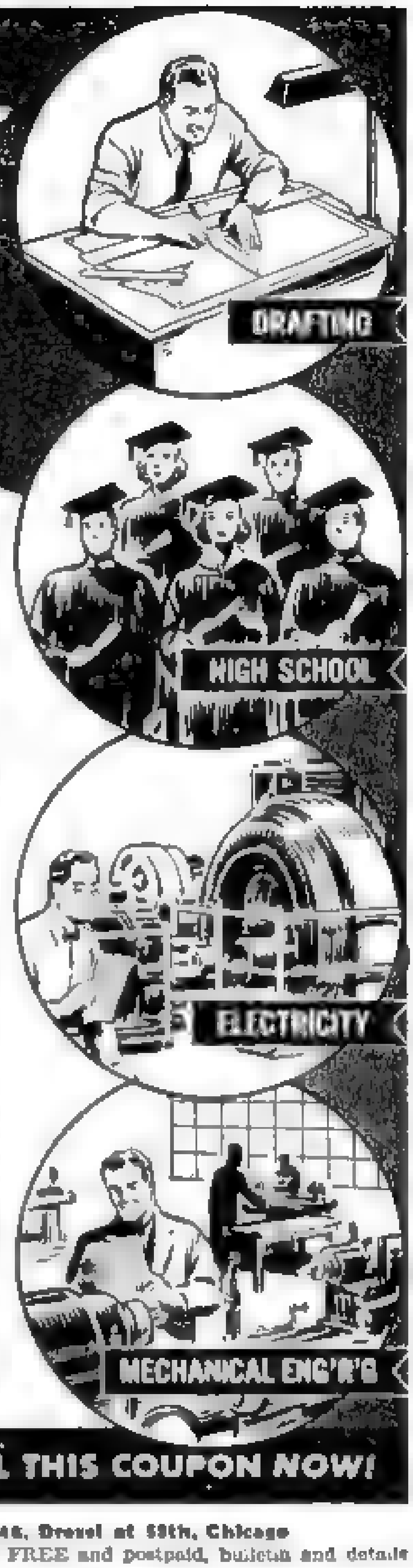
Radio "Bugs" Want a Chance to Help Win the War

Purchasing stamps and bonds, saving tin cans and paper, isn't enough for me. I feel that we radio bugs spread all over the U.S.A., experimenting and building radio sets in the home workshop, are being left out of the war effort. We may not have lathes or other power tools which are used to make parts to help the war effort, but we can do pretty well when it comes to handling a soldering iron and other tools which are used for radio work. So how about letting me and a couple of thousand other radio bugs know so we can put our radio tools and knowledge together to help win the war.—I. K., Brooklyn, N. Y.

Psychiatrists Beat Palm Readers Hands Down, This Reader Says

In a recent Readers Say, E. S. T., of Bristol, Pa., asked whether psychiatrists were not in the same class with astrologers and palm readers. This would honor the astrologers and palm readers! I think that E. S. T. should be enlightened as to the importance of workers having jobs to suit their neurotic conditions, especially under the great strain of war work today. I believe that other readers agree, as would E. S. T. if he knew the facts. As a science enthusiast, I think that your articles such as "Phosphorus" and "Another First for the Electron Microscope" are swell. Keep it up.—S. M. S., Kansas City, Mo.

Home Training helps YOU WIN!



Right Now

there is a tremendous shortage of skilled men in all branches of industry. Draftsmen, electricians, machine designers, tool makers, machinists are needed and the pay is big. Executives, too, foremen, superintendents, managers are wanted to help complete our tremendous production program.

War Production Demands Better Men

It is a duty you owe your country, yourself, and your family. You should know more and more about your job. You should be prepared to advance and to accept the responsibilities of the men ahead of you so that they in turn may climb and, climbing, take you with them. No matter what your present job, you should learn to do it better or learn how to do the job of the man ahead of you. You need to know *both theory and practice* to make our tremendous war plants more productive. Yes, indeed, you are needed and *needed badly* right now.

Draftsmen, Electricians, Machine Designers, Machinists, Foremen, Superintendents, Managers Can All Profit by Home Study... No matter what your trade or profession there is a better place for you in industry. You can get the training needed right in your own home.

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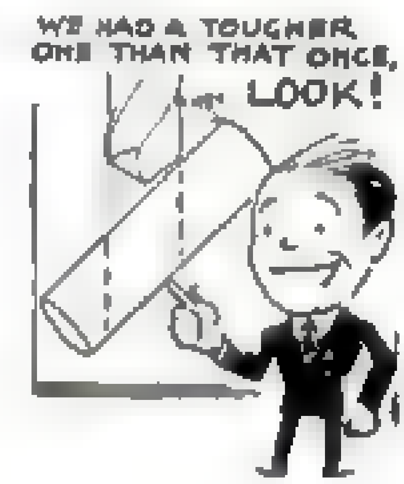

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Wanted: Wartime Work for Two Garagemen

I have been a subscriber to Popular Science for some time and have enjoyed it all, especially anything pertaining to autos. My brother and I have a garage—owning our building, which is a good size—but we are unable to keep going for long as the only income we have from it now is from repair work. We would like to know if you have heard what other garagemen are doing to help the income during the war. Either full or part-time war work, or any other work. We'd like to have any suggestions.—T. F., Beaver Dam, Wis.

From the News Editor's Desk

FROM THE LABORATORIES of the National Health Institute comes the heartening news that the famed sulfa drugs are about to reach a new high in combatting disease. Heretofore, one of the drawbacks of these drugs was that on occasion they caused agranulocytosis—a dangerous reduction of the blood's white disease-fighting cells. Experiments on rats, however, now show that the injection of liver or yeast extracts successfully counteracts all symptoms of this dread disease. Not only does this counteractant indicate the presence of an undiscovered vitamin, but it also restores sulfa drugs to their former category of the "miracle drugs."

TO PROTECT A SUBMARINE'S BATTERY-ROOM FLOOR and walls from the corrosive effects of escaping fluids and fumes, the Goodyear Tire & Rubber Company is putting a rubber-composition sheeting into large-scale production. The product, which has passed all Navy tests, will be applied in two layers, each about 1/8 of an inch thick, and will be held in place by a special cementing curing process also being developed by Goodyear.

THE LEGEND OF BRITISH IMPERTURBABILITY is made less legendary by the news that, even when they are huddled in an air-raid shelter during a German bombing, English scientists find time to argue about how much water there is in a jellyfish. Textbooks have long maintained that the fish contained 99.8 percent water. Dr. A. G. Lowndes of London, however, is determined that the fish has but 96 percent of water, three percent salts, and a trace of fats. The good doctor has also found that the poor fish has but four percent of protoplasm—the stuff of which life is made.

SCOURGE OF THE TROPICAL AREAS in which many American soldiers are now stationed is the dreaded, deadly malaria. For decades the disease has been fought off with quinine. In place of this medicine, now rendered war-scarce, comes abatine—to the tune of half a billion tablets a year. Less expensive to produce, permitting smaller dosage, equally effective as quinine in combatting malaria and more effective in preventing relapses, abatine is the answer to the Army doctors who declare, "We have four enemies: Germany, Italy, Japan—and malaria. But there is only one that can lick us."

WHEN 1942's FALL SEASON blew into Iowa with a premature frost, it started a cold-versus-corn battle which, first check-ups show, has left at least 90 percent of the state's crop the winner. This, beside being good news for stock feeding and the production of alcohol and other war materials, is also indicative of how little the rest of the crop throughout the Midwest has been affected. Being mature, all the corn needed was a bit of dry weather, and latest reports from the weather man were that the premature cold snap would be succeeded by a spell of Indian summer.

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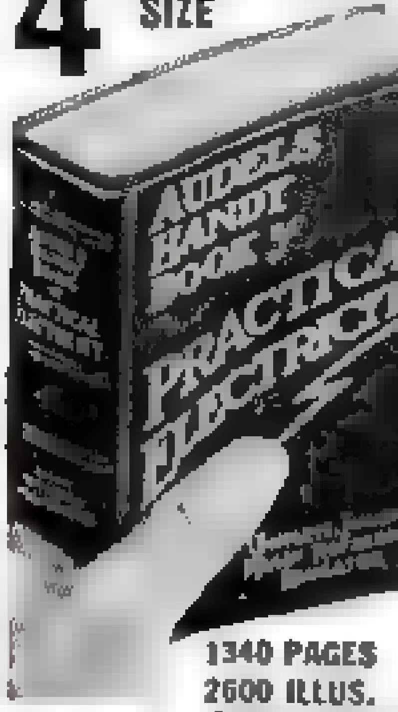

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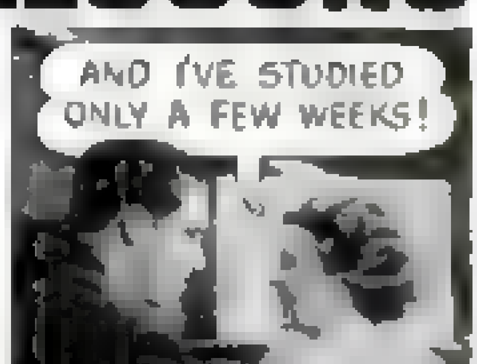

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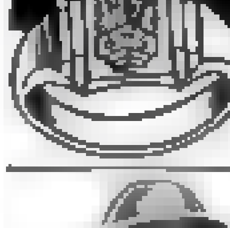

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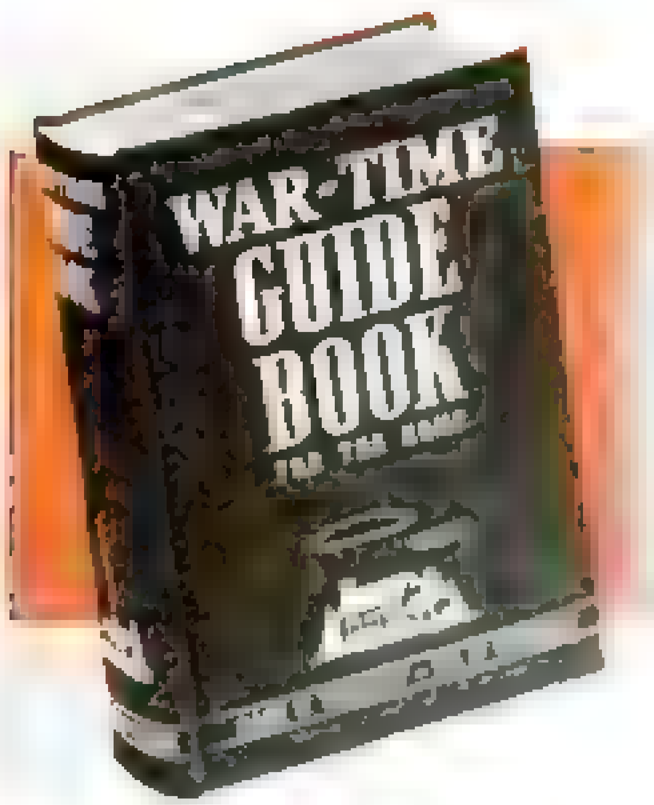

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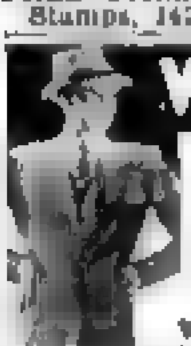

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NO — BUT ONCE I DIDN'T EVEN KNOW THAT SMOKERS GET AROUND 50 PIPEFULS FROM A POCKET PACKAGE OF PRINCE ALBERT, EITHER!
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THOSE ARE ASSAULT BOATS. SEE HOW THEY ARE NESTED ONE INSIDE THE OTHER, 10 TO EACH TRUCK
WELL, AMERICA'S BEST-SELLING PIPE TOBACCO CERTAINLY IS IN GOOD COMPANY THESE DAYS. YOU FELLOWS GET THE MOST OUT OF EVERYTHING
PRINCE ALBERT GOES FARTHER IN ROLL-YOUR-OWNS, TOO, BECAUSE IT ROLLS FAST, SMOOTH WITHOUT WASTE — AND IT SURE HITS THE TASTE-SPOT
50 PIPEFULS OF FRAGRANT TOBACCO IN EVERY HANDY POCKET PACKAGE OF PRINCE ALBERT
PRINCE ALBERT

HOW TO MAKE AN *Emergency Gas Mask*

THERE still aren't enough gas masks available to outfit all of our civilian population, and with military demands at a peak no early production on a basis of a mask for every civilian can be hoped for. Rather than go without any protection at all, the alert citizen can make gas masks for himself and his family.

Such homemade masks must be looked upon as nothing more than temporary emergency equipment. They cannot take the place of approved masks, but they should, if carefully made, afford more protection than towels, blankets, or similar

Air-Raid Protection from Common Materials

First step in making the mask is to cut a round hole on the center line of the cap, about 4" from the back edge. This hole should be about 1½" smaller in diameter than the celluloid powder-puff box

Insert the celluloid box (without its lid) in the hole, stretching the rubber over the turned-up edge and halfway across its width. Tape it fast all around. Bottom of box faces outward from the mask

Both ends of the canister must be open. Cut a disk about 1" larger in diameter from a piece of screening or a fly swatter. Hold this over one end of the canister, bend down the edge, and tape it fast

Place two handkerchiefs together and push the cloth into the canister against the screen. Pack tightly with two parts charcoal to one part soda lime and fold over the cloth. Leave wide margin all around

makeshift filters in case of a gas attack.

The Air Raid Precautions Department of the American Women's Voluntary Services, under National Director May Singhi Breen, is teaching civilians how to make gas masks from rubber bathing caps. This type of mask, designed by Dr. Simon L. Ruskin of New York City, is intended to protect the wearer only against the common, known gases used in chemical warfare. It is useless against smoke, illuminating gas, and carbon monoxide (automobile exhaust).

How such a mask is made is shown in the accompanying photographs. Use a heavy bathing cap, not a thin one. Make joints airtight so that the wearer can breathe only through the canister

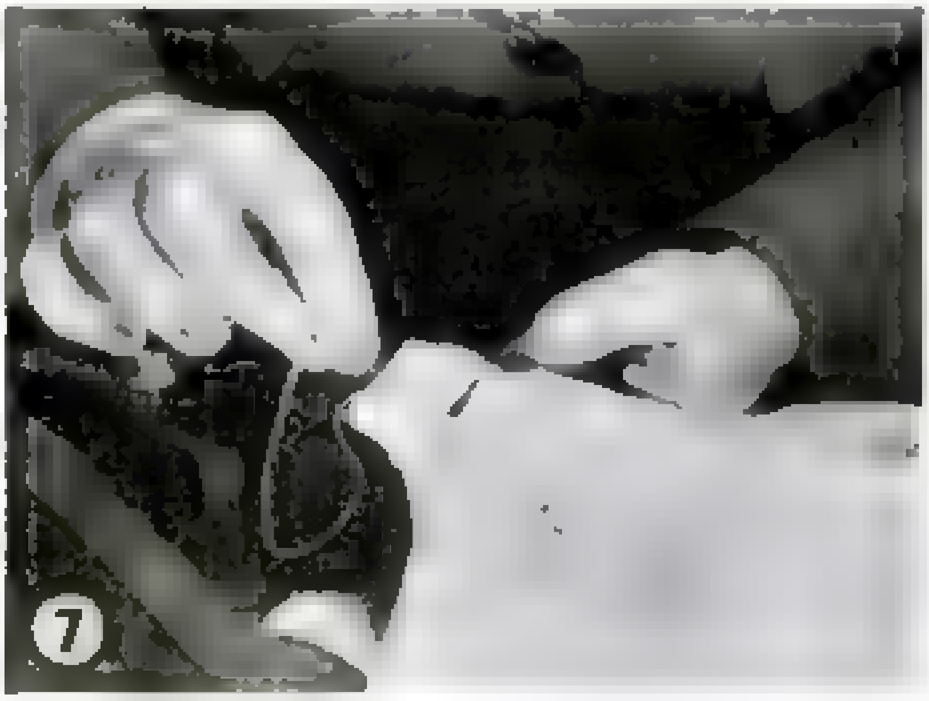
The physical filtering agent in the canister is activated granular charcoal, which can be obtained at drug stores and wholesale drug houses. To test it for acivity (the ability to take up and hold gases), place a small amount, such as a tenth of a gram, in the palm of the hand and pour on it five drops of carbon tetrachloride. The charcoal should become warm. If not, it's unsafe.

Either one half 10 20 mesh and one half 4/10 mesh, or the coarser charcoal alone, may be employed. With it mix one half as much coarse-mesh soda lime (sodium calcium hydrate), also available at drug stores. Pack the canister solidly. No air must enter without passing through the charcoal.

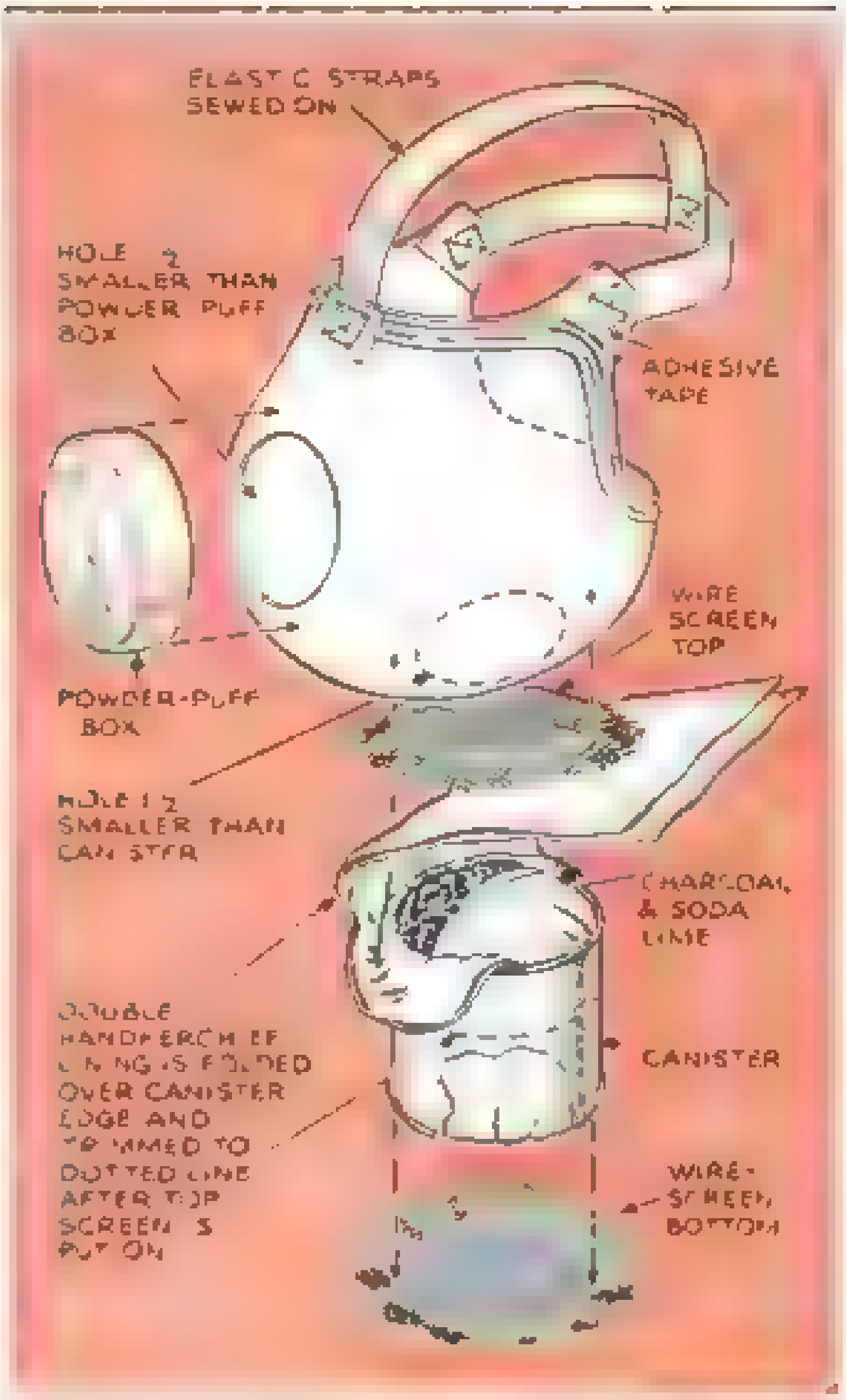
Do not forget to seal both ends of the canister with tape or heavy waxed paper. If left unsealed, the charcoal will absorb moisture from the air until it is saturated, and the mask will be useless. Unseal the canister only when the mask is to be put on for protection against gas. Once the mask has been used, the canister must be refilled with fresh charcoal and soda lime.

Cut a second disk of screening and bend it down all around over the cloth. Hold it with a turn of tape while cutting away surplus cloth. Afterward, apply more tape to hold the screening firmly on canister

Cut another hole, about 1½" smaller than the canister, in the lower part of the cap. Insert the canister and tape as with the powder box. Cover screened ends with tape to keep charcoal active

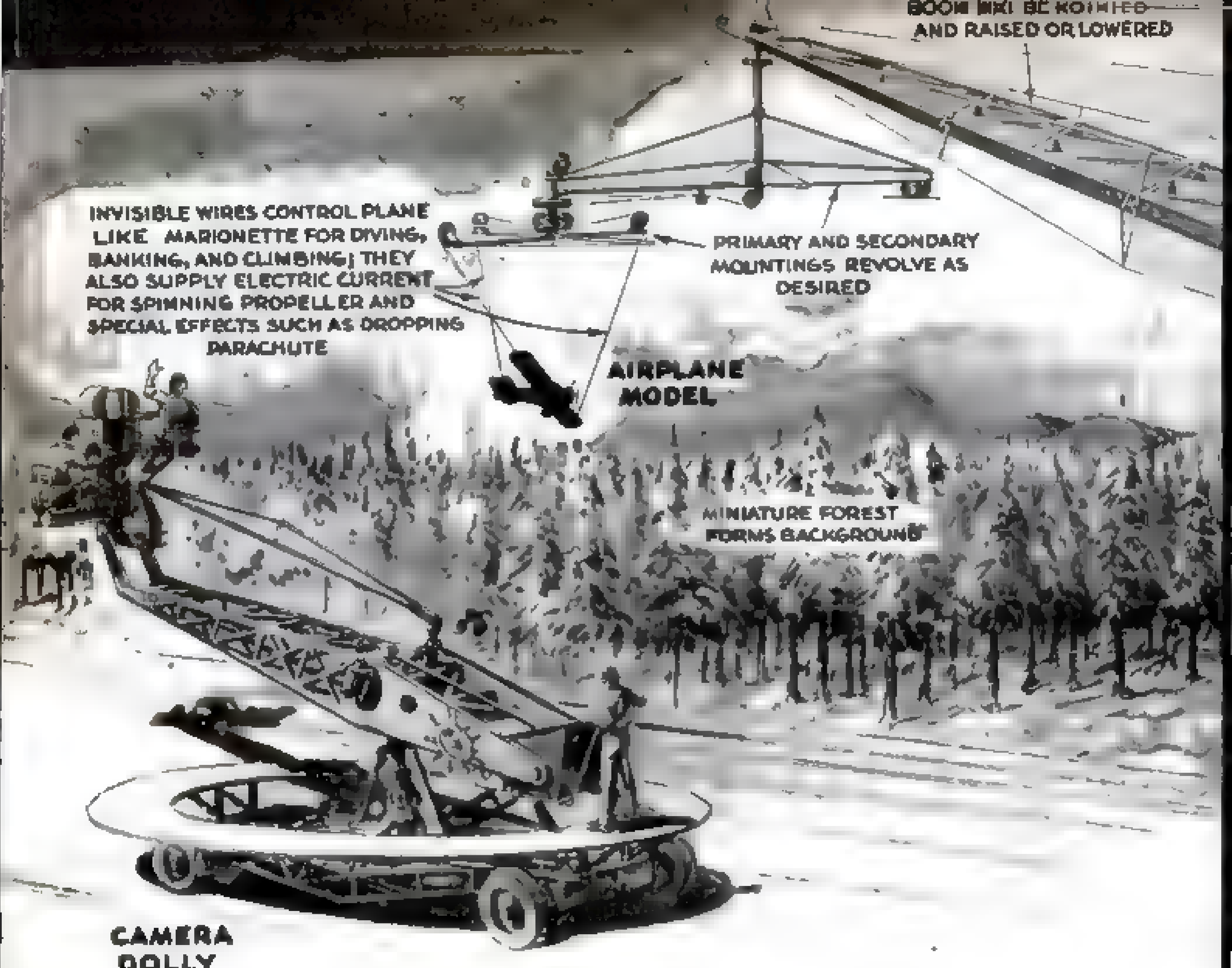


Make a head harness of ¾"-wide elastic and attach it as shown in the drawing. Try the mask on to make the straps the right length. Put a thickness of tape over the elastic, another under the rubber before sewing, to make the thread hold securely



PARTS OF FINISHED MASK, and how they are assembled. The canister is kept sealed until the mask is needed. Otherwise, charcoal loses activity

Put on the mask by hooking the edge nearest the canister under the chin. It should make an airtight seal all around the face. To test the seal, cover the canister with the hand and draw a deep breath. If all the joints are tight, the mask will collapse



Drawings by B. G. SEIELSTAD

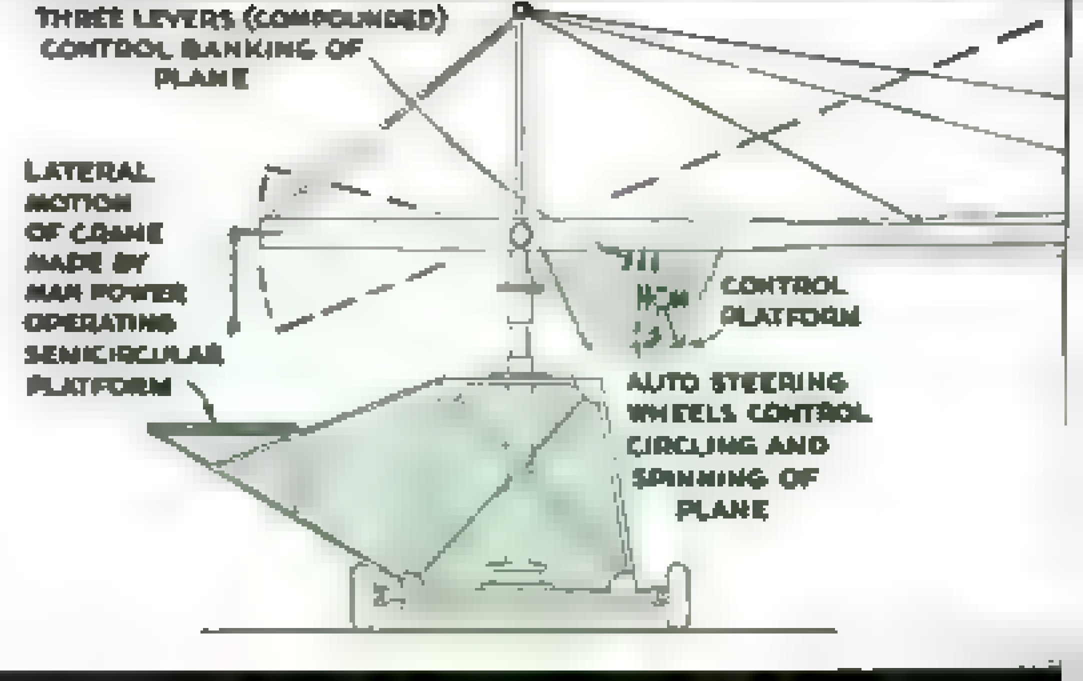
Model-Plane Boom Simulates

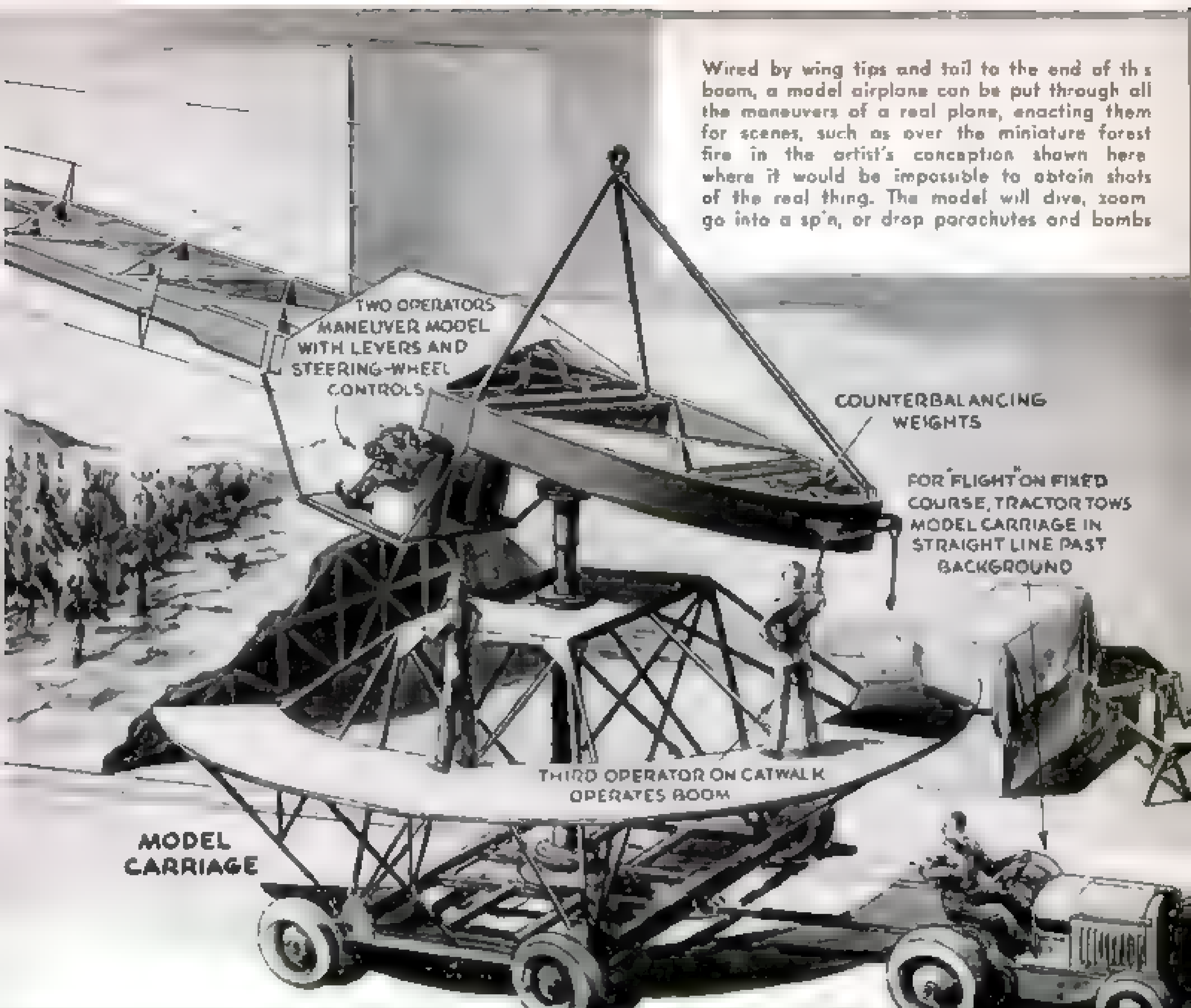
MANIPULATED like a marionette at the end of a 50-foot boom of steel and spruce, a model airplane provides realistic new movie effects for the Paramount studio at Hollywood, Calif. Three invisible wires, their thickness exaggerated for clarity in the accompanying drawings, support the miniature craft by wing tips and tail. Under their control, the model can be made to dive, zoom, or tilt at will.

Meanwhile, in doing these primary operations the scaled-down plane may also be put into a spin or made to perform other complicated evolutions through the manipulation of rotating primary and secondary mountings, controlled by a pair of operators in bucket seats on a platform below the boom arm. Another crew, working on a semicircular catwalk, raises or lowers the boom and swings it through a wide arc. For straightaway flight, the boom and plane are towed past a painted backdrop.

Wires that support the model also supply

HOW THE BOOM IS RIGGED





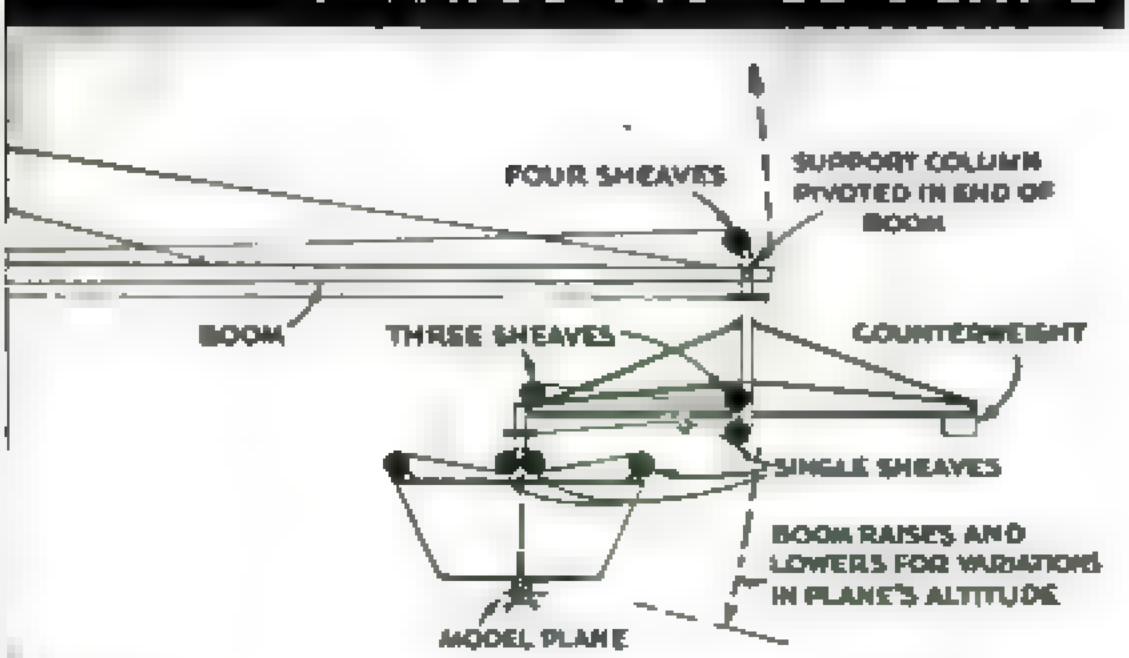
Wired by wing tips and tail to the end of this boom, a model airplane can be put through all the maneuvers of a real plane, enacting them for scenes, such as over the miniature forest fire in the artist's conception shown here where it would be impossible to obtain shots of the real thing. The model will dive, zoom go into a spin, or drop parachutes and bombs

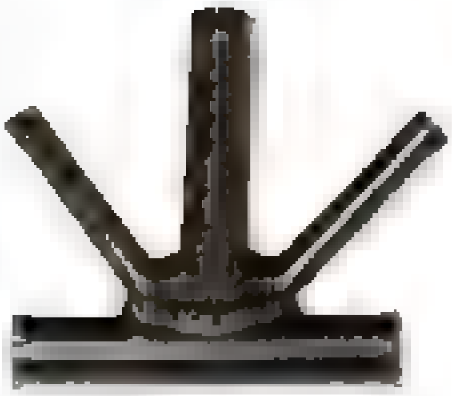
Hazardous Flights for Movies

electric current for a motor that spins the propeller, and for operating special-effect relays that enable the plane to drop parachutes and bombs, simulate machine-gun fire, and lay a smoke screen, or, if called for in the script, cause it to explode in mid-air.

Designed by Ivyl Burks, mechanical engineer for the Paramount studio, the unusual apparatus solved the problem of filming "The Forest Rangers," which dramatizes the exciting work of the U. S. Forest Service's aerial patrol. It shows planes flying low over tree tops, spotting fires, circling to determine the extent of a blaze, dashing through the smoke, and dropping men and fire-fighting equipment by parachute. Scenes such as these would be virtually impossible to photograph effectively over a real forest fire, even from another plane. In other productions, the animated model would be well adapted for portraying the maneuvers of fighters and bombers in scenes depicting air warfare.

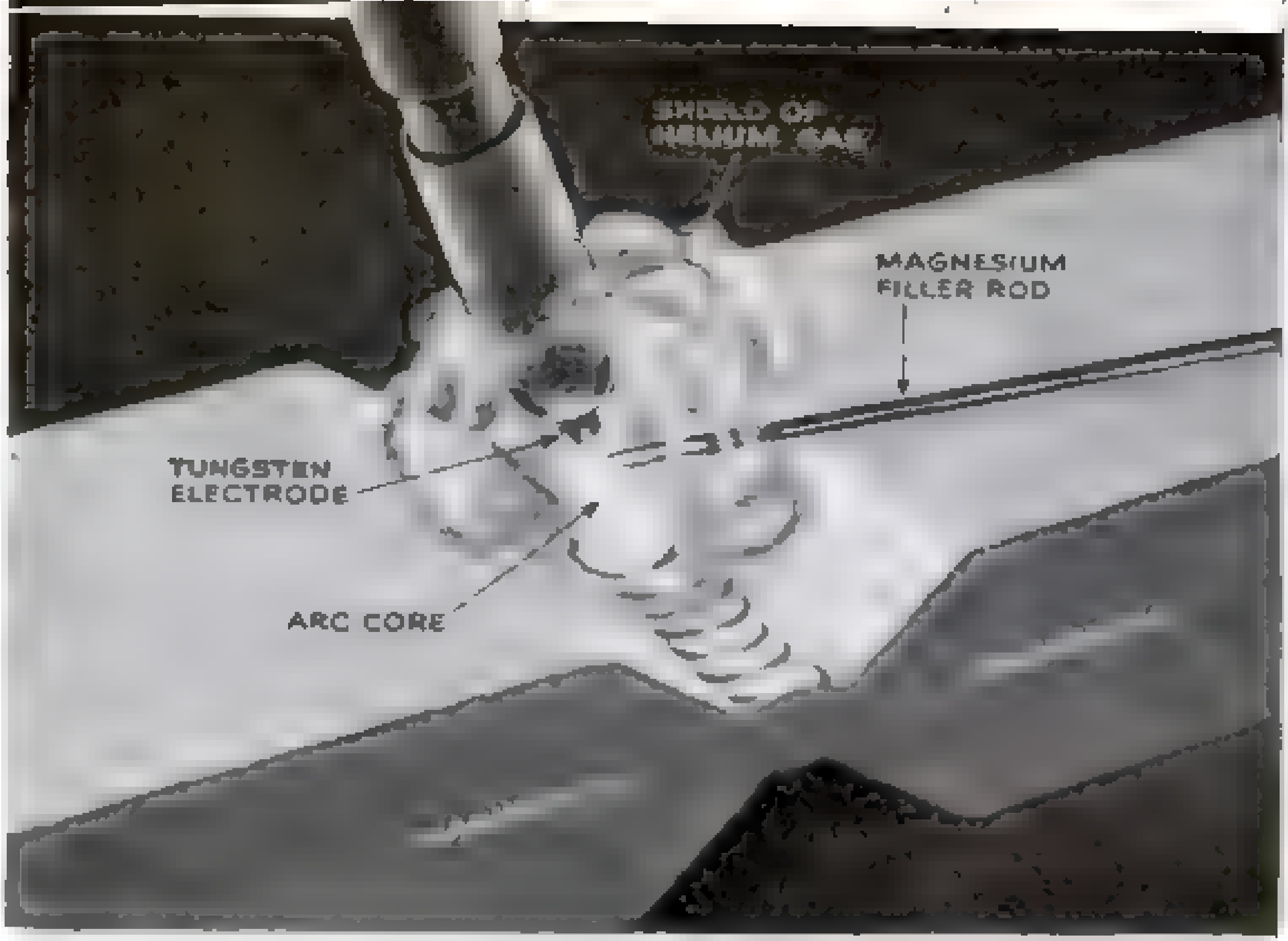
TO CONTROL MODEL PLANE





Thin magnesium tubes arc-welded at joints

This is now possible with Heliarc welding (at right). A shield of helium gas prevents the metal from bursting into flame by excluding oxygen



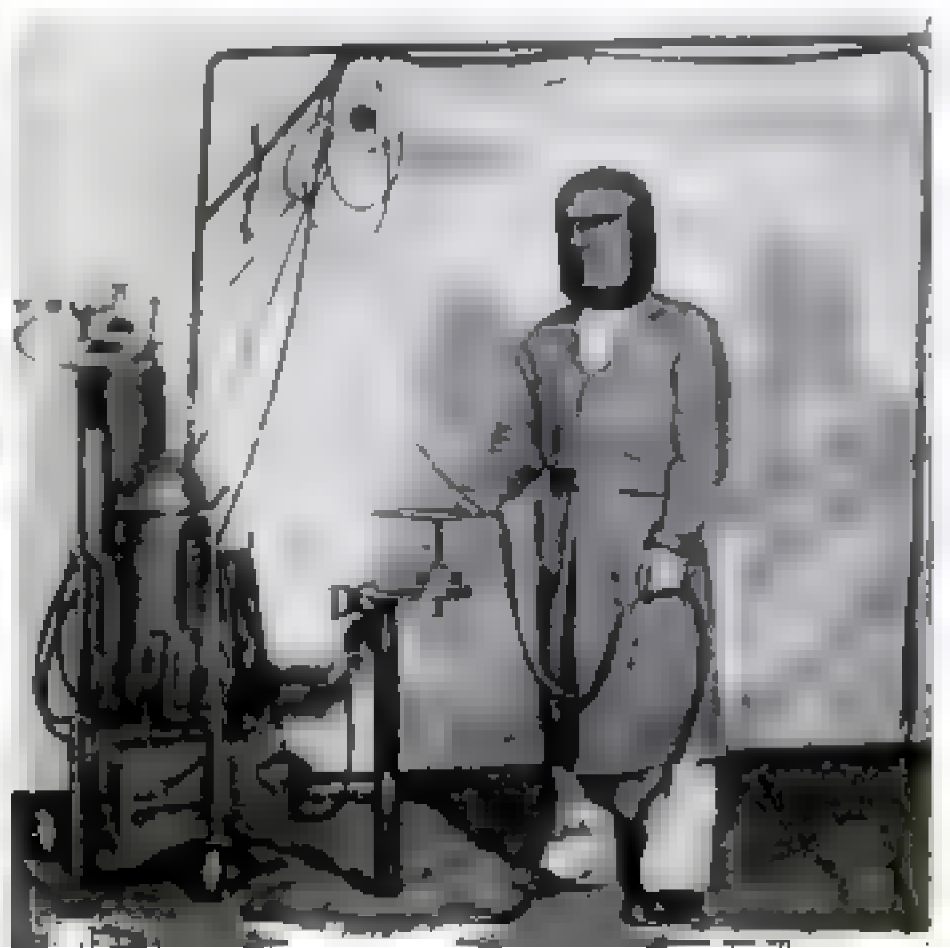
Helium + Arc Welds

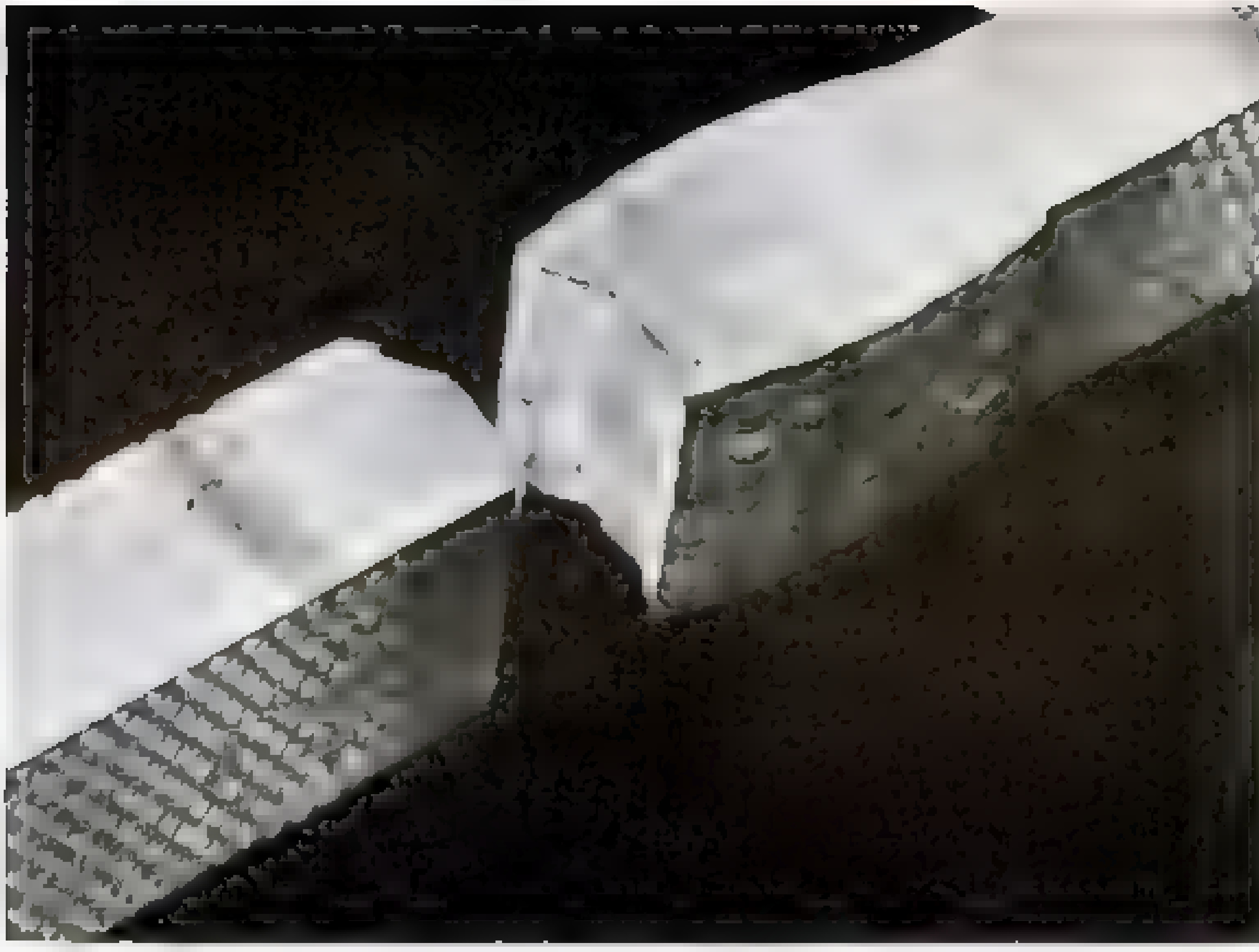
HELIUM, best known as a fireproof gas for filling balloons and dirigibles, now comes to the aid of the makers of heavier-than-air flying craft. It is being used in welding as a bubblelike shield to prevent molten magnesium from taking fire, and thereby permitting parts made of this featherweight metal to be welded into simpler, lighter, and stiffer structures for airplanes than are possible with heavier aluminum. This new use stems from two years of development by V. H. Pavlecka, chief of research, and Russ Meredith, welding engineer, of Northrop Aircraft, Inc.

Heliarc welding, as the process has been named, employs an electric torch of unconventional design. From a gas cylinder, the helium enters the tool through a duct within the electric cable. A push button controls the supply of gas to an insulated cup, from which it issues around a tungsten electrode.

To strike an arc, the operator turns on the helium and lightly brushes the electrode along the magnesium metal, which has been made a part of the electric circuit. A filler rod of magnesium, fed into the gas-blanketed arc at the electrode, builds up the weld. The thermal properties of helium, the developers say, are so superior to those

These magnesium parts for an airplane indicate the value of Heliarc welding in modern aircraft production. At the right is a typical Heliarc welding setup with its swinging overhead cable and hose support





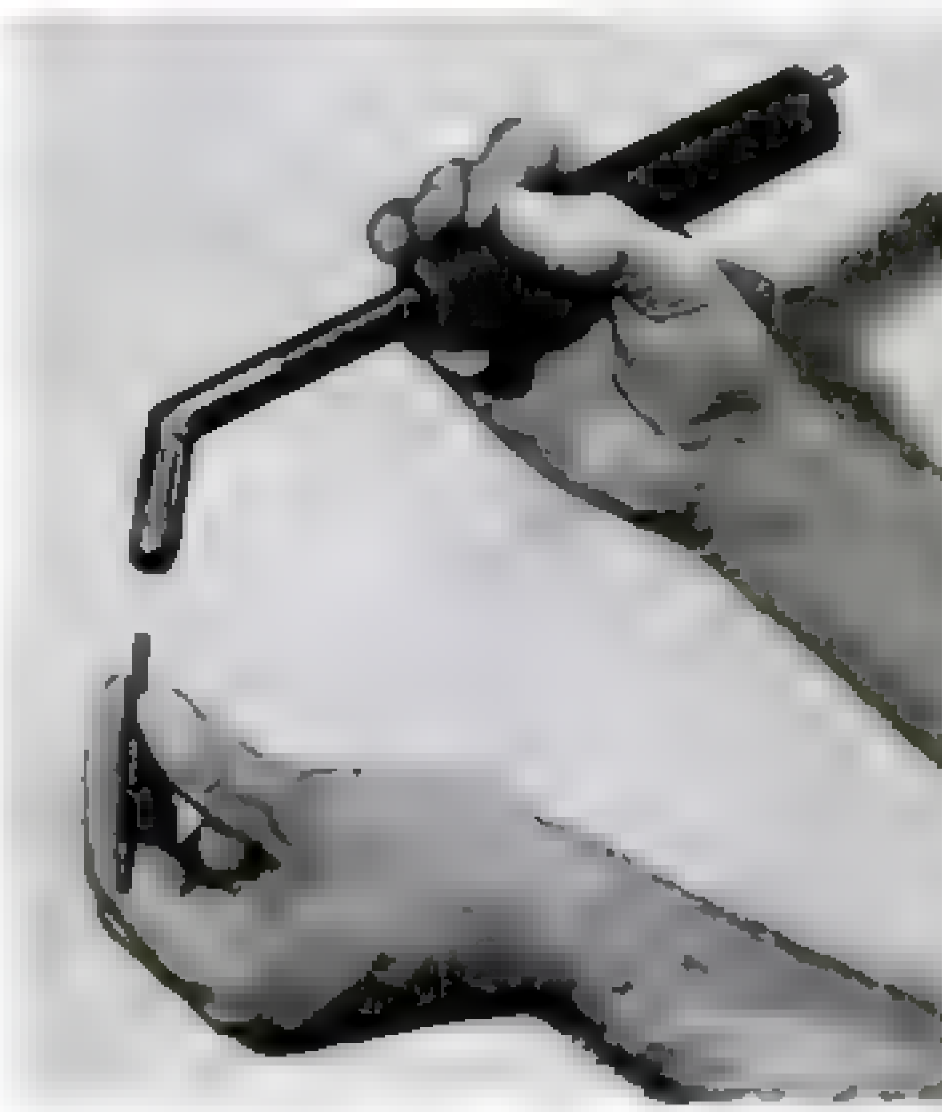
In a tensile test, a Heliarc-welded magnesium specimen breaks, as at right, in the metal next to the weld, showing the great strength of the weld itself

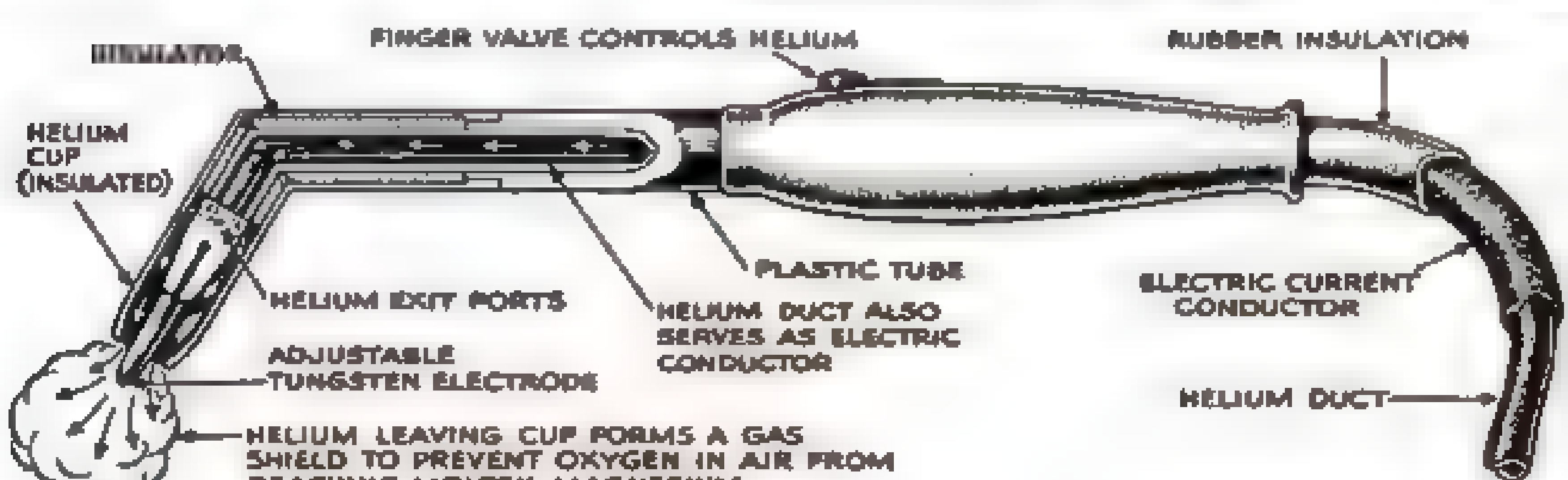
Below, a tungsten electrode is being put into the clutch at the tip of the new Northrop torch for Heliarc welding

Magnesium

of other gases that heat accumulation is prevented, welds are kept cool, and greater penetration than any other known process is provided. No flux need be used, removing the possibility of corrosion due to trapped flux.

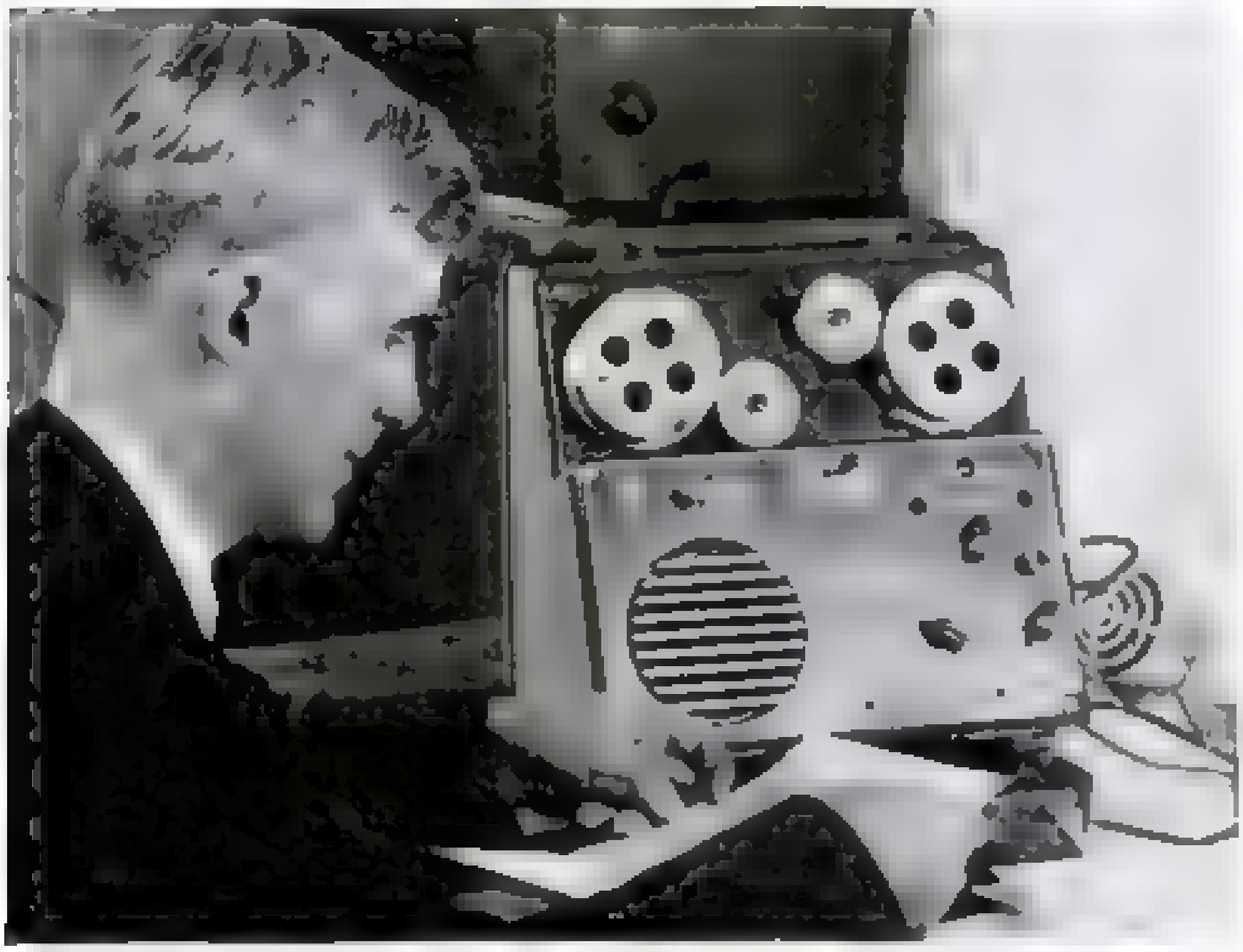
In addition to welding magnesium, the new method makes possible rapid fabrication of structures from alloys of other metals, such as the joining of magnesium to stainless steel. Stainless steel, in fact, has been one of the most difficult alloys to weld, and could be satisfactorily arc-welded only in comparatively thick sections by the use of atomic hydrogen. The Heliarc method successfully welds sections thinner than one hundredth of an inch.





Here is the unconventional electric torch for heliarc welding developed by Northrop Aircraft engineers

Thin Magnetized Wire Makes Compact Recordings

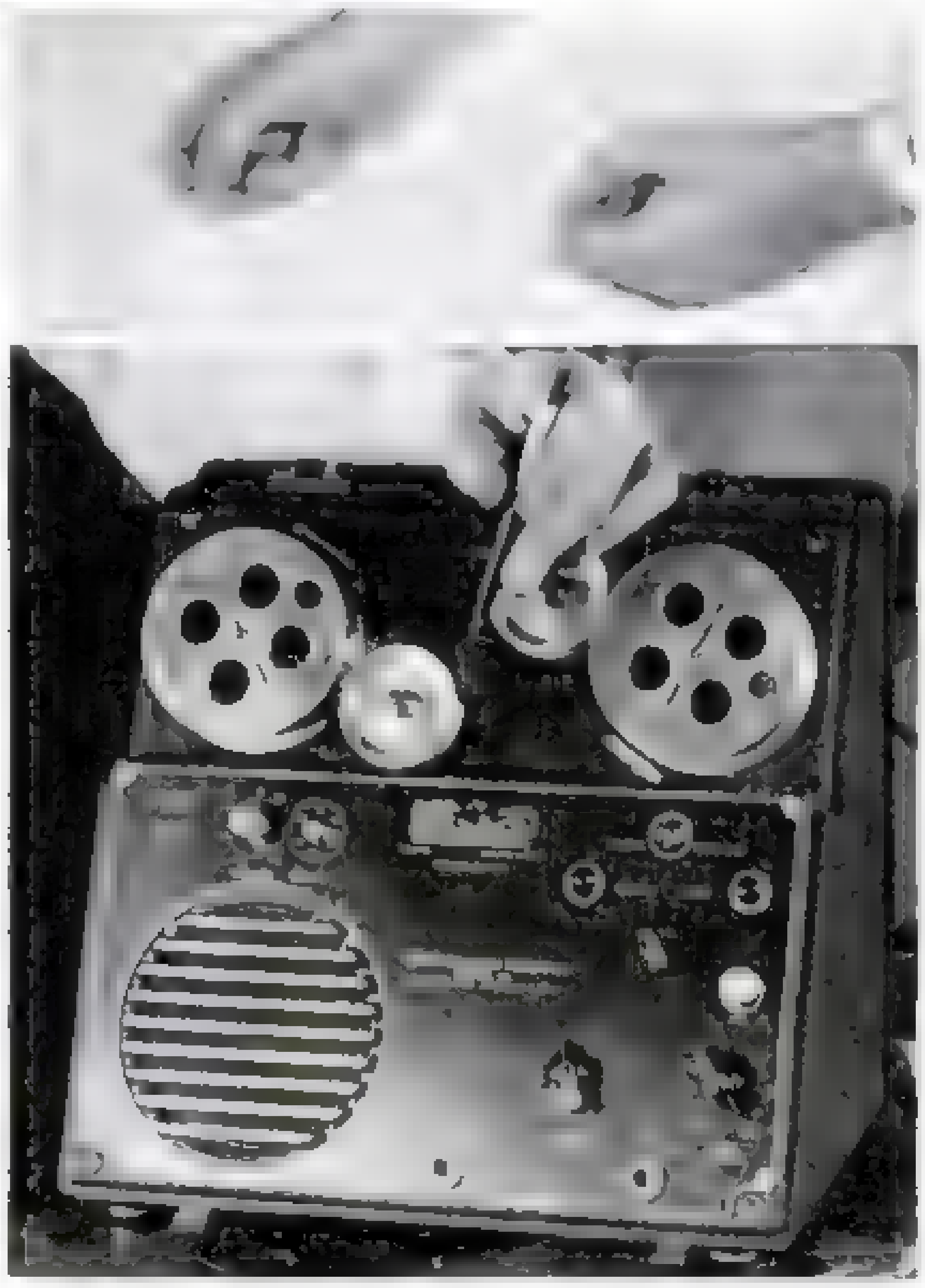


Dictation is recorded by this machine on a wire so thin that eight hours of transcription can be wound on one of its five-inch spools. Among its other uses are monitoring and home recording of broadcast programs

Below is the wire—no thicker than a hair—on which recordings are made. Sound, impressed magnetically, will last until it is "erased" by demagnetizing to permit use of the wire again

SOUND recording on hair-thin wire, compact and inexpensive, has just been perfected. As in previous systems using bulkier steel tape for dictating or for reproducing court proceedings, voices are impressed magnetically upon the metal; and they may be "erased" by passing the wire through a demagnetizer, so that it may be used over again. The new method offers one distinct advantage—a continuous eight-hour transcription can be wound upon a spool only five inches in diameter and two inches thick, a fraction of the space now required. In mass production, a complete set should cost less than $40.

Government monitoring stations could use the device to transcribe millions of words of Axis propaganda, for analysis and counter-measures. Or a radio listener could leave it set to transcribe any broadcast during his absence—a Presidential speech, a musical program, or a baseball game—and play it when he came home.

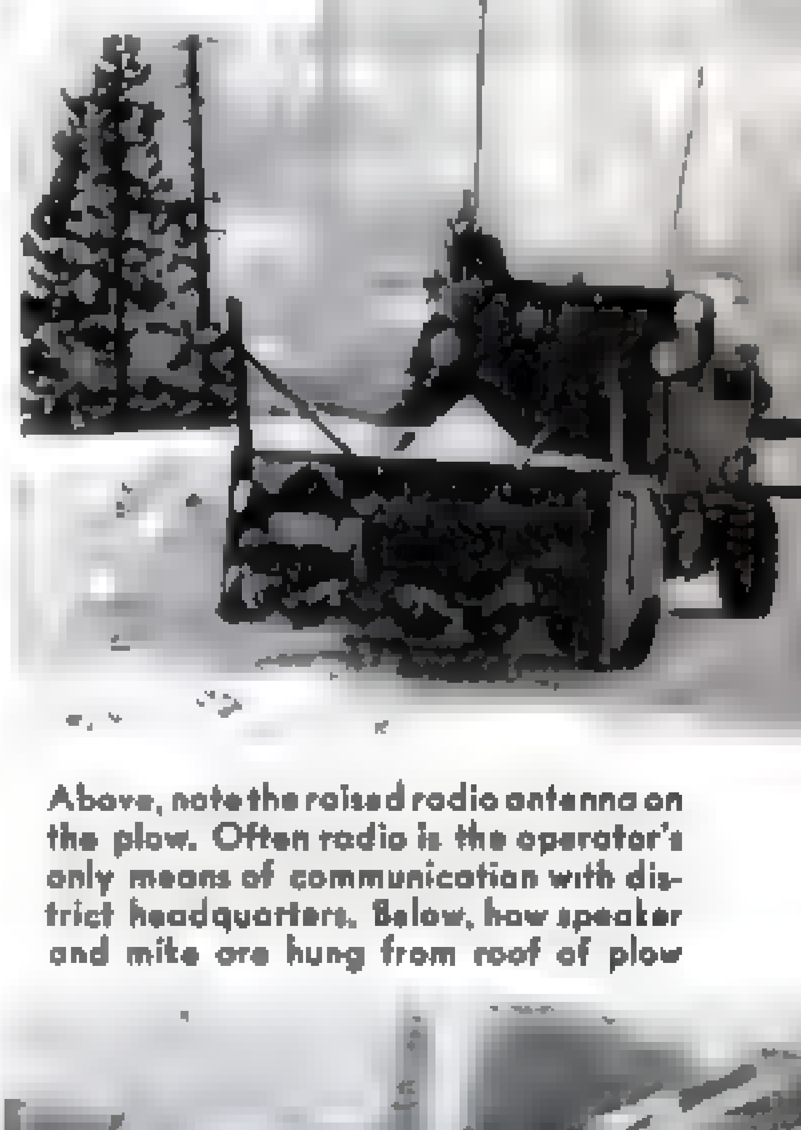


At right, the pencil points to a small magnet that impresses sound on recording wire as the metal is wound past it from spool to spool

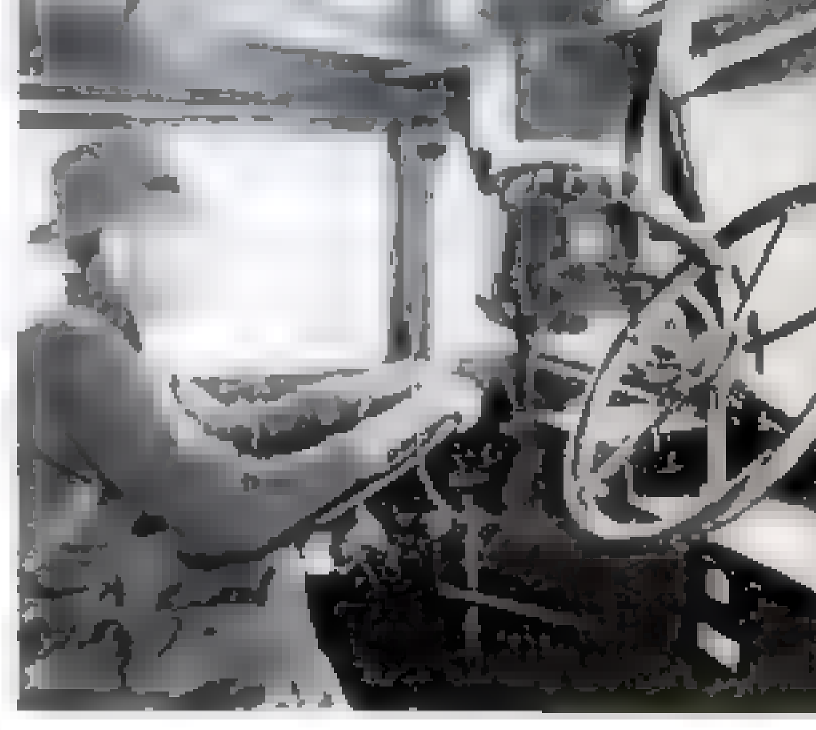
Two radio-directed snowplows, hurling aside deep drifted snow, meet on a California mountain pass

Snow Army Holding Open East-West Troop Highway

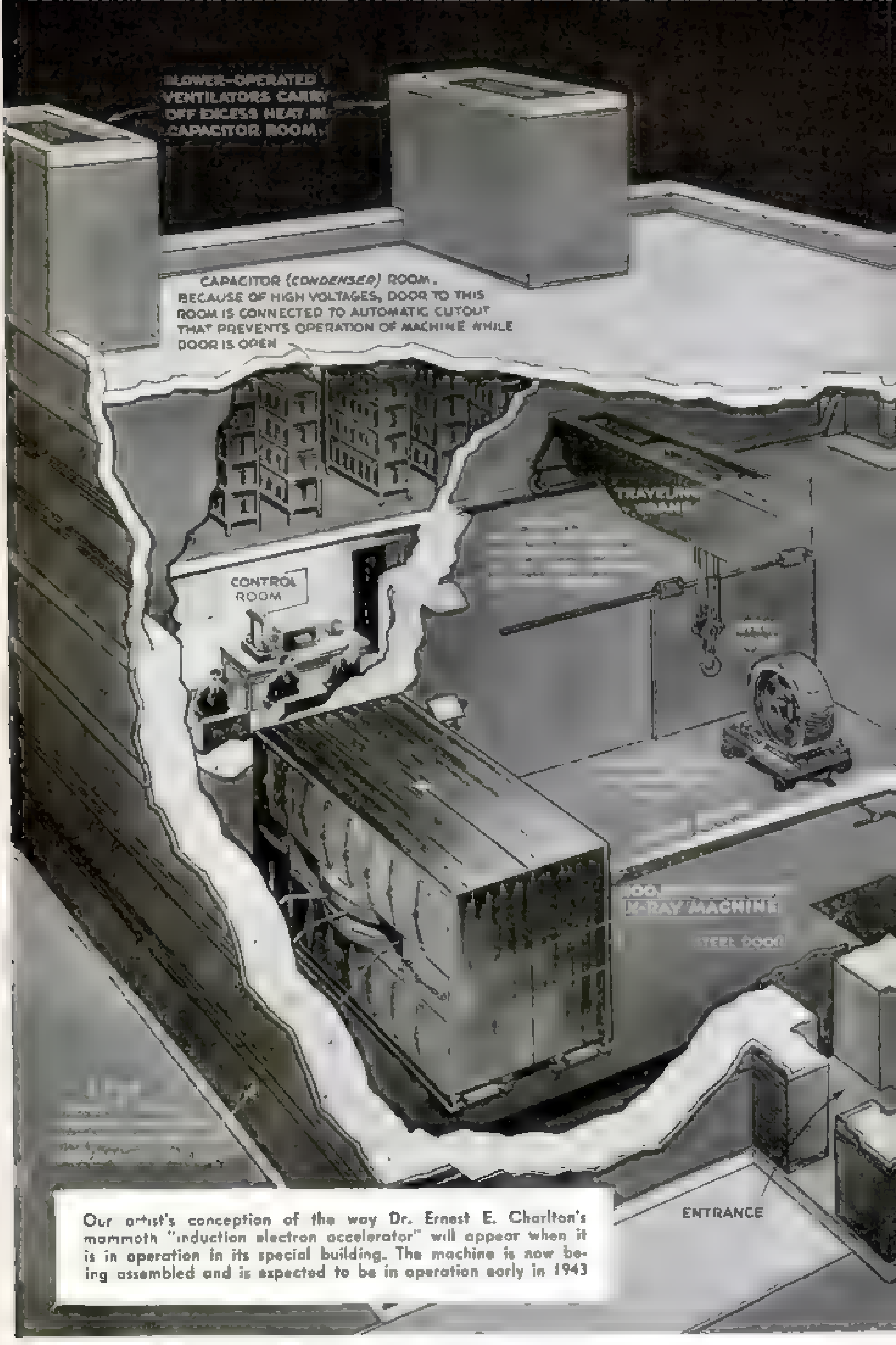
TO MAKE possible year-round troop movements over the transcontinental U.S. highway, despite 20-foot packed snow that heretofore has blocked it against winter travel through the high Sierras, an immense array of snow-battling equipment has been mustered by the California Highway Commission. Powerful two-way radios will carry communications between isolated highway workers and equipment in the mountain passes and headquarters, to speed the fighting against nature in regions where 50 feet of snowfall a year is common. The weapons include four-wheel-drive snow throwers, huge rotary plows, V-plows, light one-way plows, bar slicers, dynamite, drift fences, antiskid abrasives, and ice-melting chemicals.



Above, note the raised radio antenna on the plow. Often radio is the operator's only means of communication with district headquarters. Below, how speaker and mike are hung from roof of plow

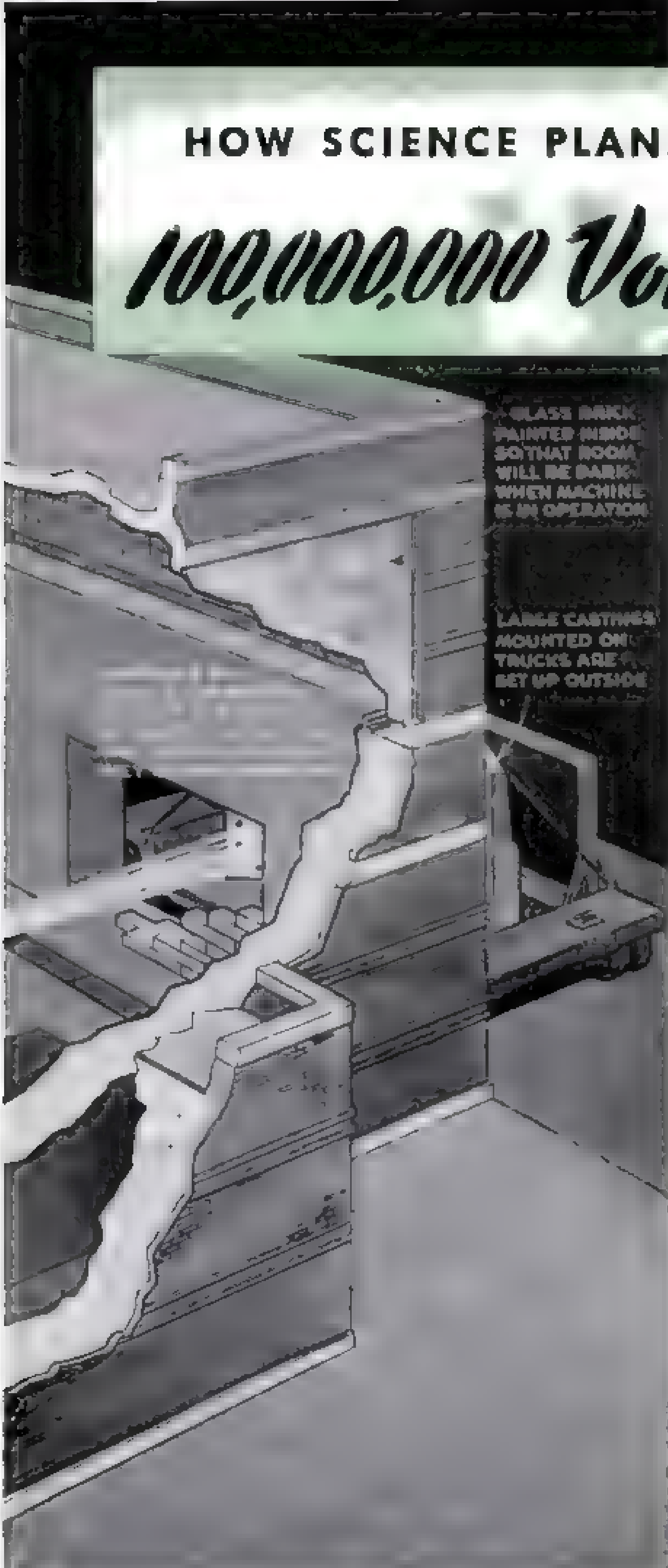


In wake of scraper follows the truck-mounted slicer bar (below) to trim high banks and prevent later cave-ins. The slicer cuts into vertical snow walls to form a stable, sloping embankment



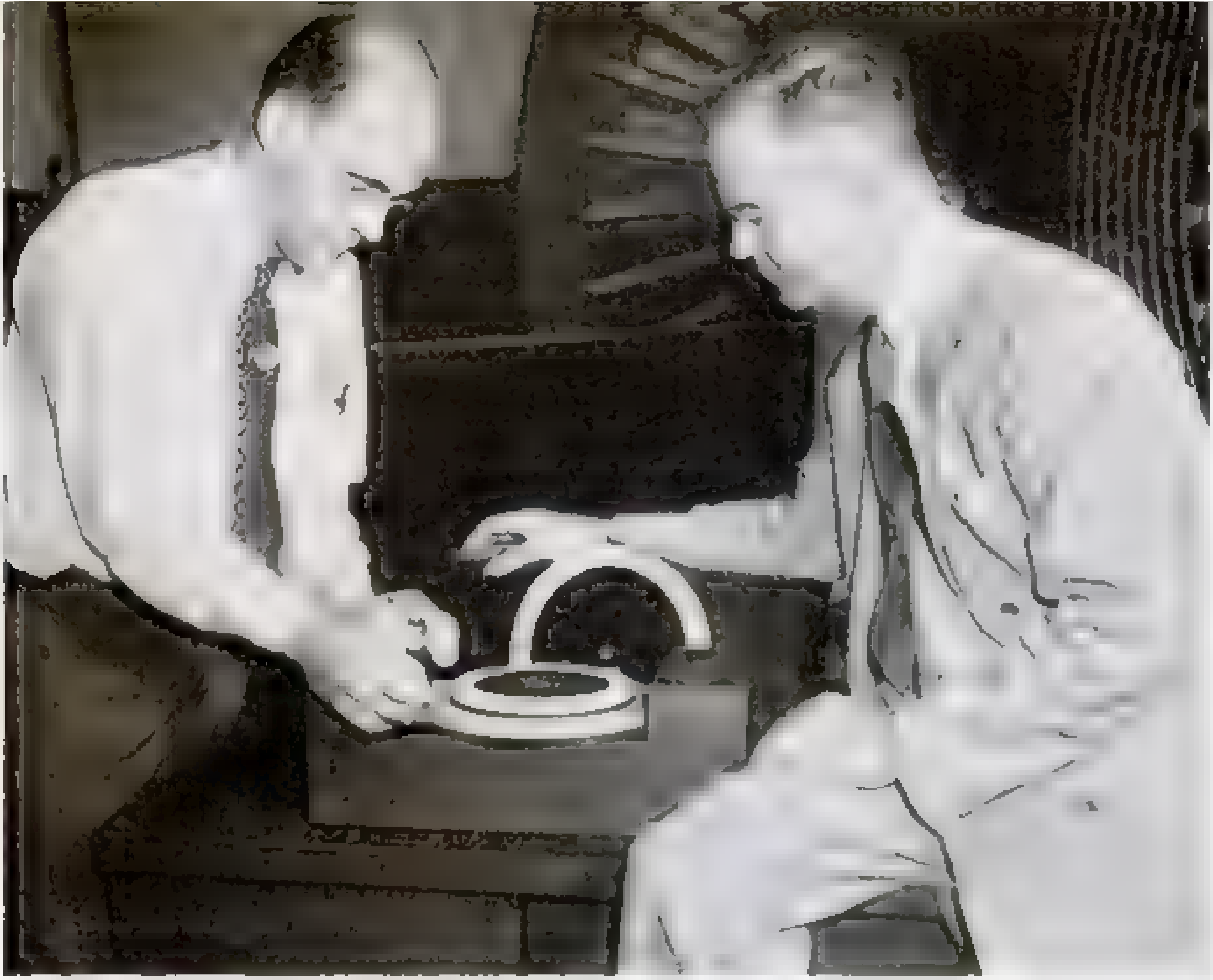
Our artist's conception of the way Dr. Ernest E. Charlton's mammoth "induction electron accelerator" will appear when it is in operation in its special building. The machine is now being assembled and is expected to be in operation early in 1943

HOW SCIENCE PLANS TO CAGE A 100,000,000 Volt Giant



DR. ERNEST E. CHARLTON, of the General Electric Research Laboratory, who periodically builds "the most powerful X-ray machine in the world," is now constructing the giant of them all—a 100-million-volt unit which will discharge electrons and X rays of such penetrating power that it is to be housed for adequate protection in a specially constructed building with three-foot walls. Details of this latest development in the evolution of ultra-high-voltage X rays were revealed for the first time during a recent visit of the National Inventors' Council to the General Electric plant at Schenectady. The unit is expected to be in full operation soon after the first of the year.

The new machine has been described by Dr. W. D. Coolidge, Director of the Laboratory, as "an important new tool for fundamental research," and ultimately will be devoted mainly to that purpose. A more immediate use, however, will be to help solve several urgent problems which have arisen in connection with the American war effort. Perhaps the most important of these is an accurate determination of the maximum thickness to which X rays can be usefully applied in the examination of armor plate and other very thick pieces of steel. The practical limit of the present one-million-volt industrial X-ray unit is approximately eight inches, so that it has never been possible to examine thoroughly the much thicker plates of metal that are used



Dr. Ernest E. Charlton (at right) and W. F. Westendorp study a model of the mammoth machine. The upper half is removed, revealing the vacuum doughnut through which electrons will speed at almost the velocity of light

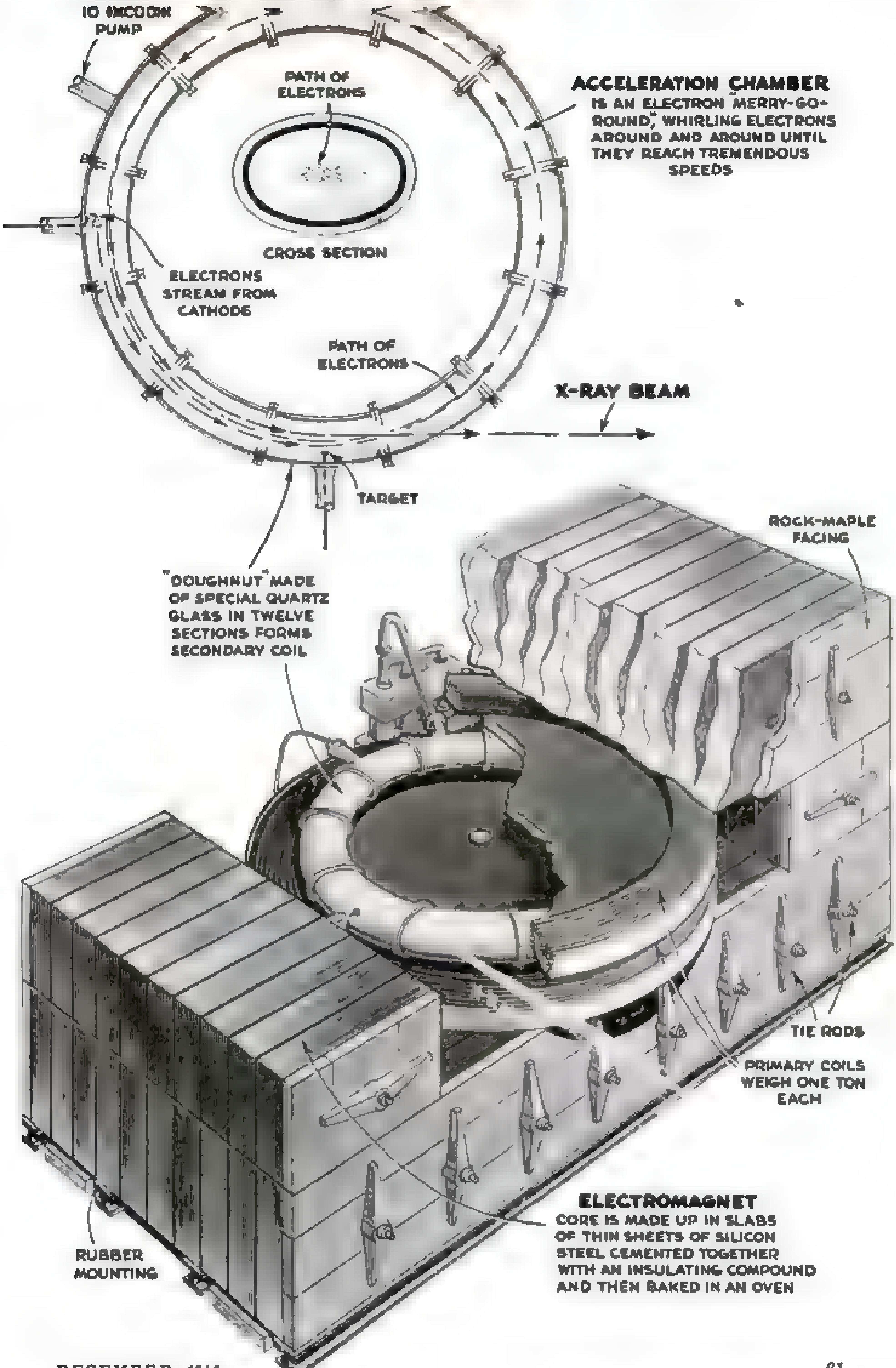
on warships and in other large constructions.

The penetrating power of X rays increases as the voltage increases, but theoretically there is a limit. Since the new unit will yield X rays at any desired voltage from one to 100 million, it should be possible to determine this thickness limit (which will vary with the material X-rayed) and to determine the practical voltage to produce the necessary quality of radiation to do the job. Engineers will find such knowledge of great value in designing future machines for purely industrial uses.

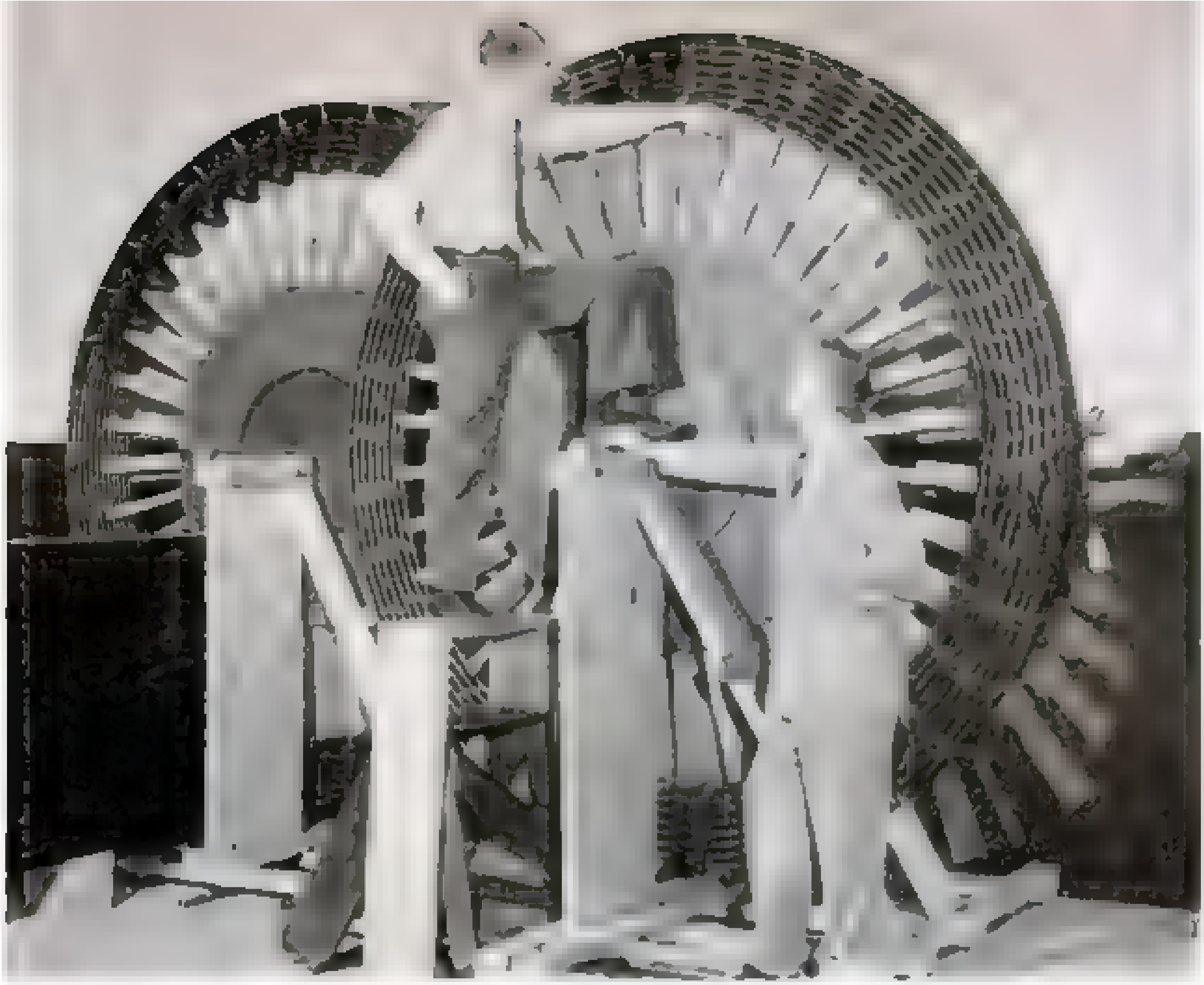
While the X rays produced by the 100-million-volt apparatus will be of far greater penetrating power than any ever known, actually to call it an X-ray machine is to misname it. Dr. Charlton and W. F. Westendorp, who are working together on the design and the construction, call it an "induction electron accelerator," and point out that it will be used not only to release X-ray radiation over a range of wave lengths never produced before in a vacuum tube but also to speed up electrons and discharge them at higher energy levels than has ever been done before. The electrons will emerge from the machine at a velocity closely approaching that of light. They can be employed for research in this form, or used to produce these shorter X rays by electronic bombardment of metal targets.

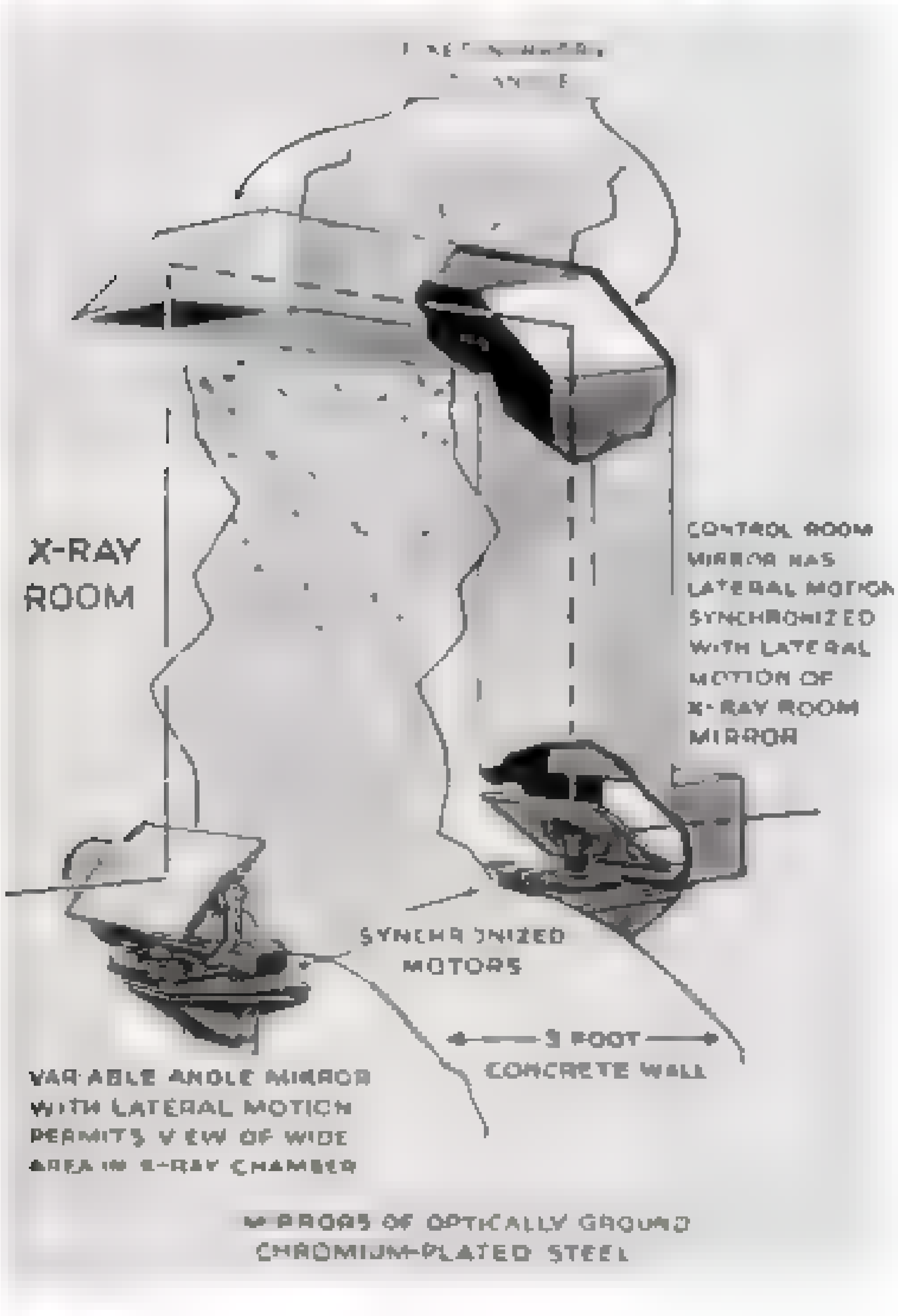
Although the new machine is far more powerful than any device hitherto used to accelerate electrons or other subatomic particles, it is, on the whole, comparatively small. As can be seen from the illustration which appears on the opposite page, the main part of the machine consists of an electromagnet. The unit works on alternating current, hence the magnetic assembly could not be made of solid iron because there would be too much loss of energy. Instead, it is constructed of a large number of silicon-steel sheets, each of which is extremely thin, held together by a special cement to form large slabs.

A six-foot doughnut-shaped vacuum tube of hard glass, called an "acceleration chamber," will be placed between the two pole faces of the magnet at the center, where the magnetic field is most intense. The cross section of this tube is elliptical, five inches high and eight inches horizontally, and the



PUMP
PATH OF ELECTRONS
ACCELERATION CHAMBER
IS AN ELECTRON "MERRY-GO-ROUND," WHIRLING ELECTRONS AROUND AND AROUND UNTIL THEY REACH TREMENDOUS SPEEDS
CROSS SECTION
ELECTRONS STREAM FROM CATHODE
PATH OF ELECTRONS
X-RAY BEAM
TARGET
ROCK-MAPLE FACING
"DOUGHNUT" MADE OF SPECIAL QUARTZ GLASS IN TWELVE SECTIONS FORMS SECONDARY COIL
TIE RODS
PRIMARY COILS WEIGH ONE TON EACH
ELECTROMAGNET
CORE IS MADE UP IN SLABS OF THIN SHEETS OF SILICON STEEL CEMENTED TOGETHER WITH AN INSULATING COMPOUND AND THEN BAKED IN AN OVEN
RUBBER MOUNTING

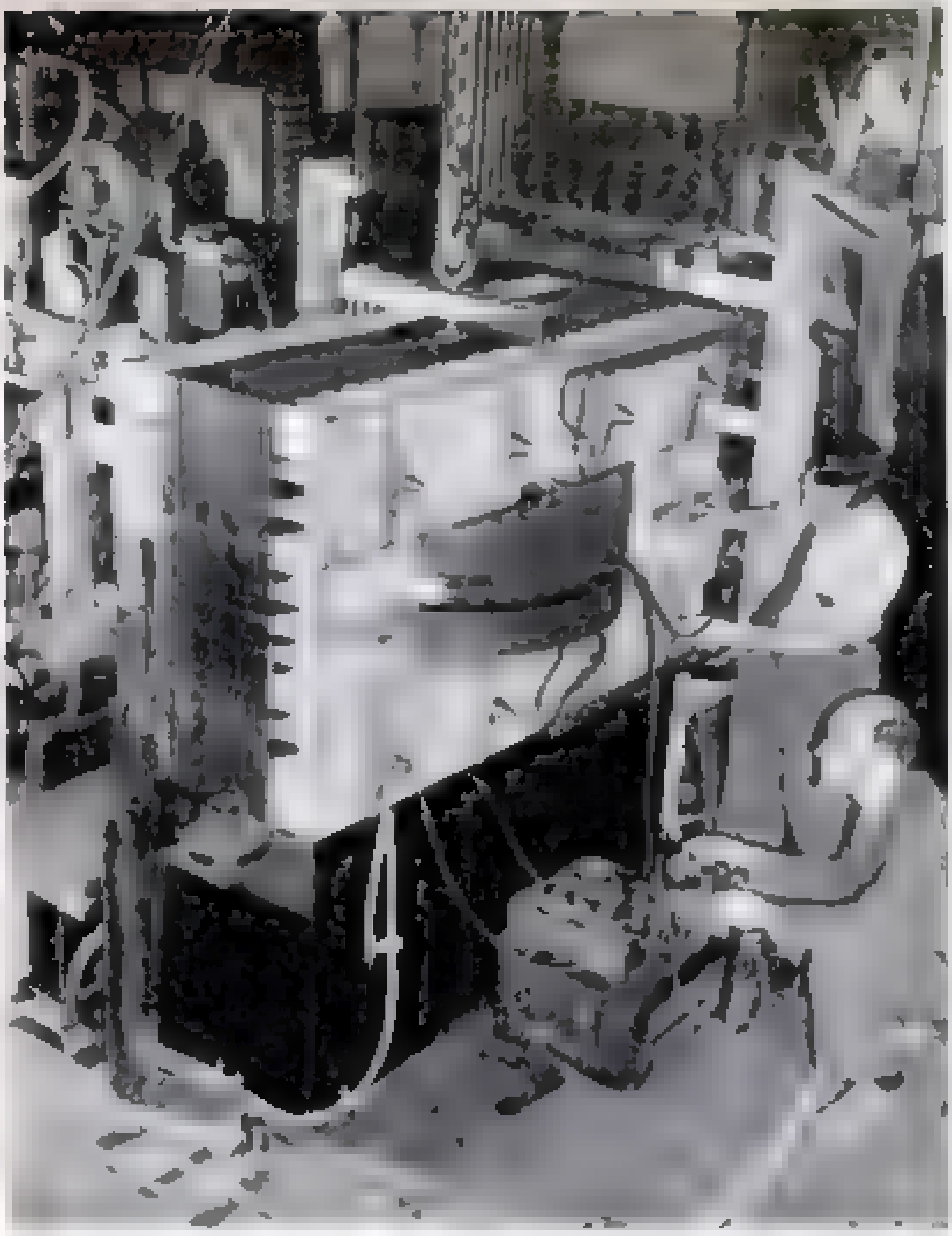




These two huge coils will form the primary winding of the apparatus, which in operation resembles a transformer. At left are details of the periscope with which workers will watch the machine in safety

walls will be about one-fourth inch thick. It will be made of 12 molded sectors manufactured by the Corning Glass Works. It will act as a sort of merry-go-round inside which the electrons, injected into it by means of an electron gun containing an electrically heated filament, will be speeded in a vacuum. They will be whirled around approximately 250,000 times in 1/240 of a second, receiving a 400-volt push on each trip and traveling a total of about 800 miles. The path of the speeding electrons must be guided with extreme accuracy, a task which Dr. Charlton compared to "shooting on a curve for a distance as great as from Schenectady to Chicago and hitting a three-inch target." This focusing problem has been solved in the detailed design of the magnet.

In general the operation of the induction electron accelerator will resemble that of a transformer, which consists essentially of two



Most powerful machine of the kind previously built by General Electric was this 20,000,000-volt unit. The new job is smaller in proportion to its power

coils of wire around a steel core. Through one of these coils, the primary, current is passed, and another current comes out of the other coil, the secondary. If the secondary contains twice as many turns of wire as the primary, the final voltage is twice as great as that originally applied. The primary of the induction accelerator consists of two 98-inch coils of insulated copper conductor 0.88 inch in diameter, each coil having 40 turns of wire and containing a ton of metal. The interior of the doughnut vacuum tubes acts as secondary, since the electric current, which consists of a flow of free electrons, can be guided in the magnetic field to travel in space without a conductor as well as between the atoms of a conductor.

The building in which the new unit is to be installed is a massive structure of reinforced brick-faced concrete about 47 by 50 feet and 34 feet high with heavy steel doors and a brick-faced wall of concrete over three feet thick extending six feet below the level of the floor. In a large section of the wall, where the X-ray beam will strike, facing a vacant lot, concrete blocks are laid without cement, so that they may be removed if they become troublesomely radioactive. This section may also be removed to permit X-ray examination of objects too large to be taken into the machine room, and for experiments with the X-ray and electron beams at various distances from the machine. In the main machine room will be placed a crane capable of lifting 60 tons, which will be used for assembling and servicing the accelerator.

Because of the dangerous nature of the radiations, no one will be allowed in the machine room while the accelerator is in operation. The control panel will be in another room, with similarly thick walls, and the operator will watch the unit by means of a periscope using four mirrors. By moving the mirrors with motors it will be possible to make observations while conducting experiments with any object placed in the beam of radiation, and to study the effect. Above the control room is installed the largest single bank of capacitors, or condensers, in the country, operating with 24,000 volts and 1,000 amperes and having a capacity of 24,000 kva.

The 100-million-volt accelerator is the second such machine to be built by General Electric. An earlier small unit capable of accelerating electrons corresponding to about 2,000,000 volts was successfully built by Dr. Donald W. Kerst in his laboratory at the University of Illinois. The next, of 20,000,000 volts, was completed about a year ago in the General Electric Laboratory with the assistance of Dr. Kerst. It has since been loaned to the University of Illinois, where Dr. Kerst is carrying out experiments with it.

In addition to their work with the X-rays, Dr. Charlton and his associates will investigate other possible fields of application of the X-rays and high-velocity electrons. The accelerator will also be utilized to make experiments in the field of artificial radioactivity. As a research tool the machine also possesses possibilities which Dr. Charlton now labels "unknown," but which will be thoroughly explored.

The construction of the 100-million-volt induction accelerator rounds out a cycle of development which began some 14 years ago, when the General Electric Research Laboratory was sectionalized and Dr. Charlton took charge of the X-ray division. The first outstanding achievement of this section was a 200,000-volt X-ray tube in which hard glass was used for the first time. This was followed by a (Continued on page 220)

NECESSITY CREATES OUR *Inventions*

NEW METHODS AND MATERIALS DICTATED BY WARTIME NEEDS PROVE BETTER THAN THE OLD

By ARTHUR C. MILLER

NEW manufacturing techniques and materials are fighting their own war on our home front, moving up in every business sector to replace scarce minerals and products needed for the nation's direct war effort.

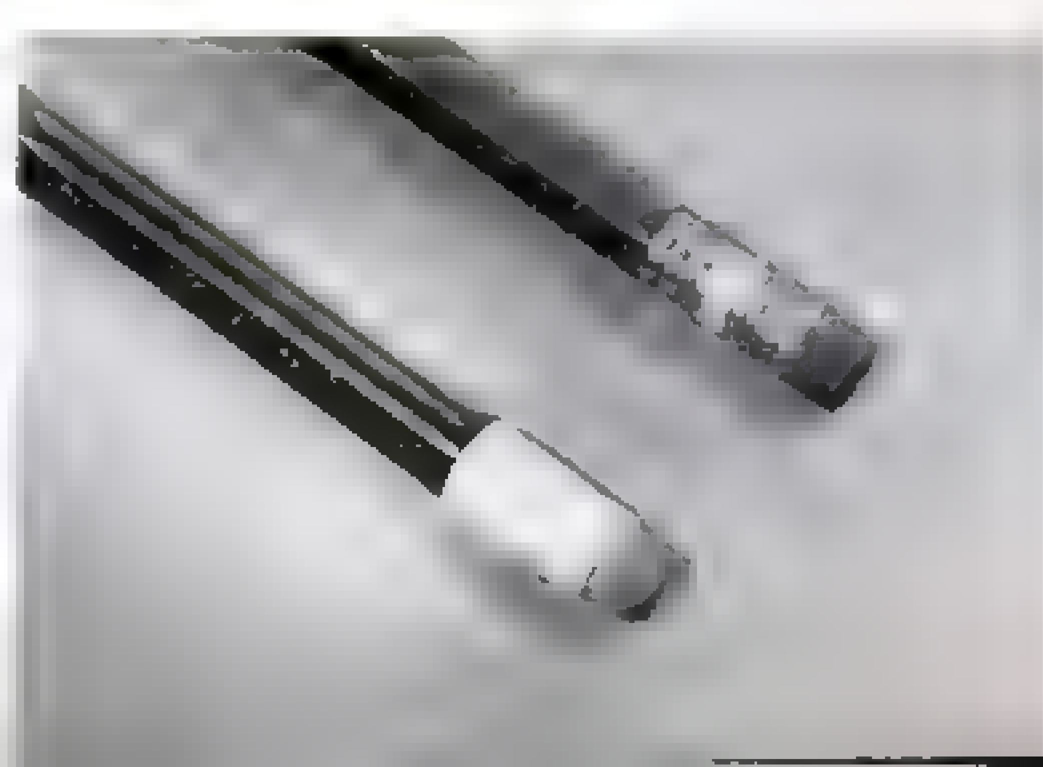
Americans will be using these new products on an unprecedented scale. And in many cases they are going to make the pleasant discovery that these are not merely substitutes or stopgaps for the old products, but that they are actually superior—lighter, stronger, handier, or better-looking.

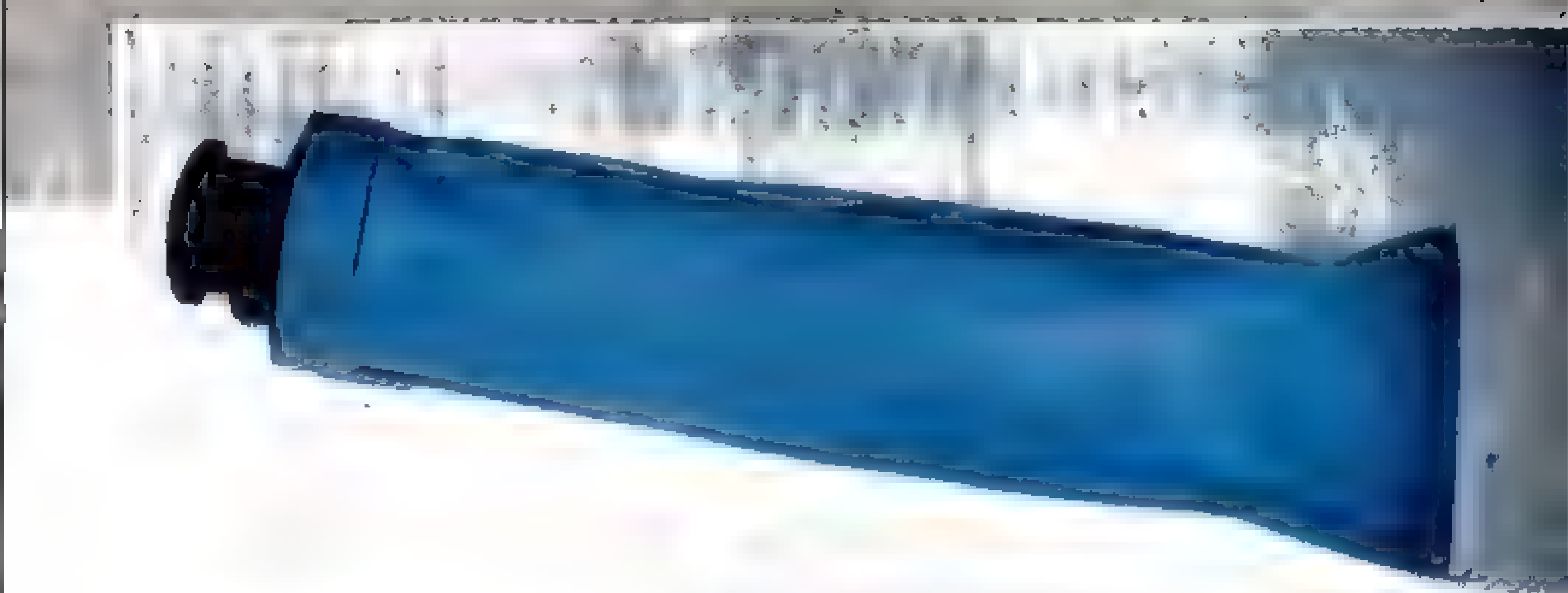
The war emergency has given industry a healthy shaking up, and has brought to the top ideas, techniques, and discoveries that had been kept on the shelf. The old ways worked well enough in normal times, and the shift to new techniques often forces changes in plant layout or machinery. But now that industry's technical advance has been pushed along at a faster rate, it is a safe bet that many of the old ways and materials won't have much chance of making a comeback after the war.

OIL SPOUT AND CAP. Plastic spouts with colored friction-fit caps screw onto standard jars in which oil companies sell lubricants

TENNIS BALLS are now being made without any crude rubber. The new ball has a fluffy, all-wool surface and bounces like the old ones

PENCILS come with erasers of resin, oil, and gum instead of rubber. The collar or ferrule is plastic which doesn't tarnish as the brass ones do





COLLAPSIBLE TUBES of plastic, developed by Harry Waters, replace tubes of tin for packaging grease, salves, ointments, and cosmetics. They are transparent or translucent like the two samples at right, or can have color baked in

The ordinary office pencil, for example, looks and wears better in its new form, with an eraser not of rubber but of resin, oil, and gum, and the collar or ferrule of plastic which can't discolor or tarnish as the old brass collar did.

Rubber has disappeared from many other common products. Floor runners, mats, and stair treads are being made from an asphalt composition. A pretty good tennis ball is being made entirely of new materials, without a scrap of crude rubber in it.

A synthetic-resin plastic replaces rubber in Army raincoats, hospital sheeting, gas-protective cloth, life-preserver jackets, and water bags. The saving of rubber in raincoats alone for our projected army of 10,000,000 men would be 17,500,000 pounds.

A rubberless typewriter roller is on the market, and existing rollers can be reprocessed to last for several years.

Copper has virtually disappeared in new products. Cooling systems have substituted coils of a clear, translucent plastic. Non-tarnishable plastic screens keep insects out, while small electric motors are wound

FRYING PANS and pots of ceramics are beginning to make their appearance in the kitchen. The makers say they give food a better flavor than metal pans

CANNED GOODS aren't canned any more, when they come in sealed glass containers. Besides saving the iron and tin, they let you see what you're gett ng

OIL CANS were traditionally made of copper or brass, but of course that's out now. Instead, we have oil cans like this, pressed from a transparent plastic. They are said to be as sturdy as metal, and a glance tells you just how much oil you have

PAINT CANS are among the many kinds of containers that are now being made of special fiber board. For holding paints, the material is impregnated with an insoluble substance. Laminated with cellophane, the cans are used for packing fruit juices

Now They're Making It of . . .

Here's a list of common articles you use or meet up with in your everyday life. Within a few months (if you haven't already) you'll be seeing them in new forms—and you'll probably approve the change!

	1940	1943
Raincoats	Rubber	Plastic
Insulation	Rubber	Plastic
Sprinklers	Brass	Plastic
Compasses	Brass	Plastic
Bearings	Brass	Wood
Doorknobs	Brass	Plastic
Bolts	Metal	Wood
Nuts	Metal	Wood
Washers	Metal	Wood
Faucets	Brass	Plastic
Food Cans	Steel	Fiber Board
Paint Cans	Steel	Fiber Board
Bathtubs	Steel	Plywood
Tool Boxes	Steel	Plywood
Downspouts	Metal	Wood
Gutters	Metal	Wood
Stirrup Pumps	Metal	Wood
Freight Cars	Steel	Fiber Board
Window Screen	Copper	Plastic
Cooling Coils	Copper	Plastic
Electric Wire	Copper	Silver
Oil Cans	Copper	Plastic
Ashtrays	Copper	Plastic
Flashing	Copper	Asphalt
Pencil Erasers	Rubber	Gum Resin
Tennis Balls	Rubber	Gum Resin
Floor Mats	Rubber	Asphalt
Stair Treads	Rubber	Asphalt
Typewriter Rolls	Rubber	Resin

with silver wire instead of copper. The old copper and brass oil can has given way to a new translucent plastic model, fully as strong, which shows at a glance how much oil is left.

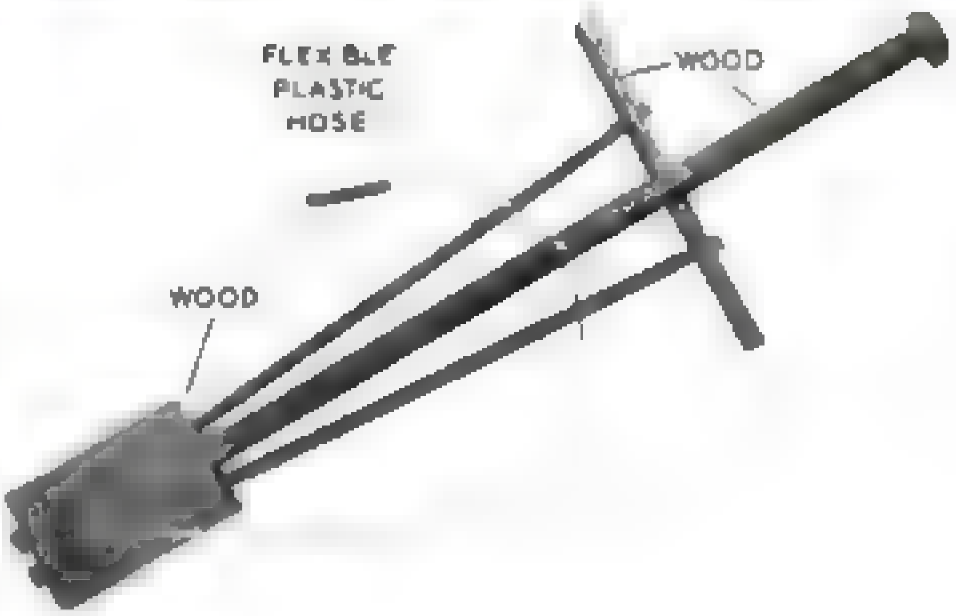
Copper flashing, used to keep joints and other vulnerable parts of houses tight and dry, is replaced by a tough, durable, and water-repellent material consisting of a felt core, bonded on both sides to an asphalt-saturated cotton fabric as flexible as rubber sheeting. This saves labor costs, by the way, as it can be formed by hand on the job and makes possible quicker, easier installations.

Attractively colored plastics take the place of brass in doorknobs and other household hardware, while even hose nozzles and sprinklers are being turned out in tough, unbreakable plastic material.

Inexpensive brass compasses, used in scientific and school laboratories, used to come from France. With imports shut off and metal unobtainable, a manufacturer of laboratory supplies has come up with a newly designed compass case molded of transparent methyl methacrylate resin, which gives both top and side visibility. It is unbreakable under normal working conditions and will not discolor with age. In the two smallest models the cover is molded

SPRAY EQUIPMENT doesn't have to be made of "critical" materials. The handy little device seen in use at the right for spraying flowers with insecticide contains little or no metal or rubber: pump, tube, and nozzle are all of plastic. Nozzles and couplings for all types of hose, from the garden variety to the kind firemen use, are also being made of plastics instead of brass

STIRRUP PUMP. The fire-bomb douser shown below is an example of the surprising new uses that are being made of man's oldest material—wood. The pump is of all-wood construction, even to the pistons and cylinders; the tube is plastic. Operation is illustrated in the drawing. The long rod is braced against the stomach. One hand pumps the handlebar, the other holds the nozzle

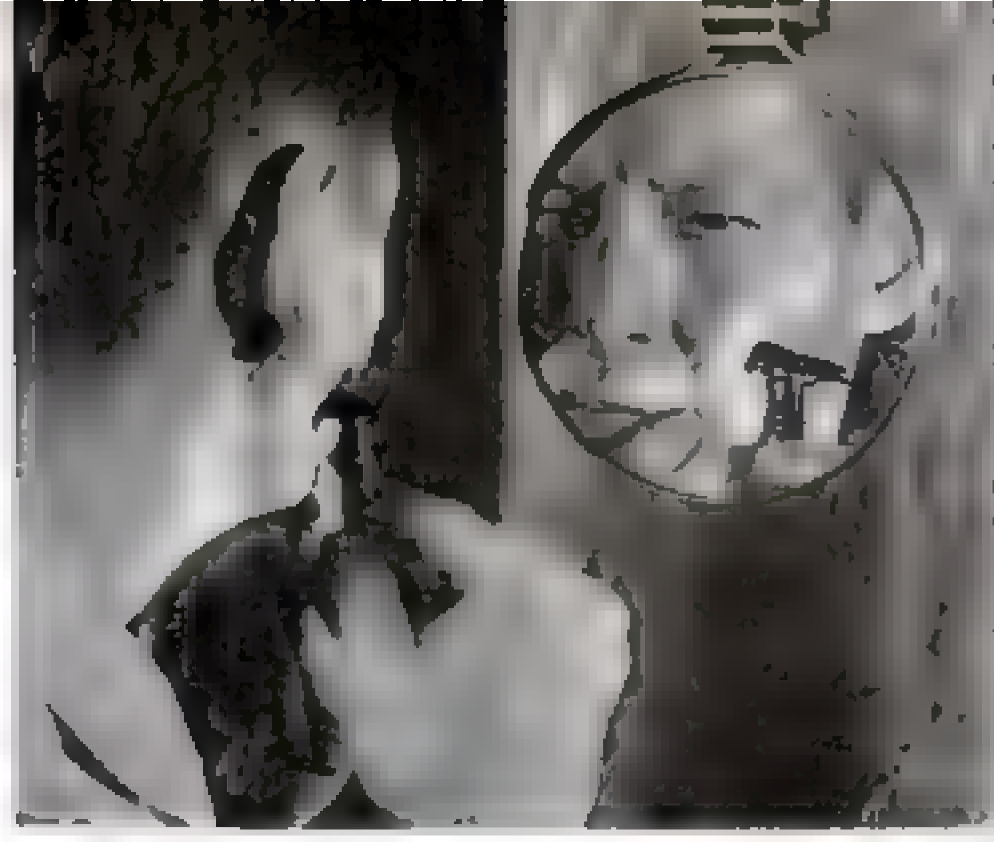


to form a magnifying lens over the tiny dial.

Steel is desperately needed for ships and tanks, so new bathtubs are made of laminated plywood, coated with a new plastic paint designed to provide as lasting a finish as porcelain enamel. The stenographer's "steel" copyholder is now made of pressed cardboard. The 1942 war worker's tool box is built of plywood finished in green or black enamel. Plywood also is used in kitchen cabinets. Canada is even trying out 750 lightweight freight cars with fiber-board siding instead of steel.

Packaging foods and other perishable products without steel and tin is a major challenge now being met with characteristic American ingenuity. New cans are being made of special fiber board, laminated with cellophane for liquid products such as fruit juices, or impregnated with an insoluble substance for paints, oils, or solvents.

Bright hope of the coffee packers is a cellophane-lined paper bag, 10,000,000 of which are now on order. The package is moisture-proof for a reasonable period, and saves not only metal but shipping space and weight. The cellophane-laminated bag weighs less than two fifths of an ounce (about 1/13 as much as a coffee can) and 10,000,000 of them will save 1,600 tons of metal for war



SAFETY RAZORS can be made of plastic as well as of brass or other metals, necessity teaches us. And we learn in the process that the new product shown below, has some decided advantages including lighter weight, lower cost, and the possibility of achieving greater variety in design and coloring

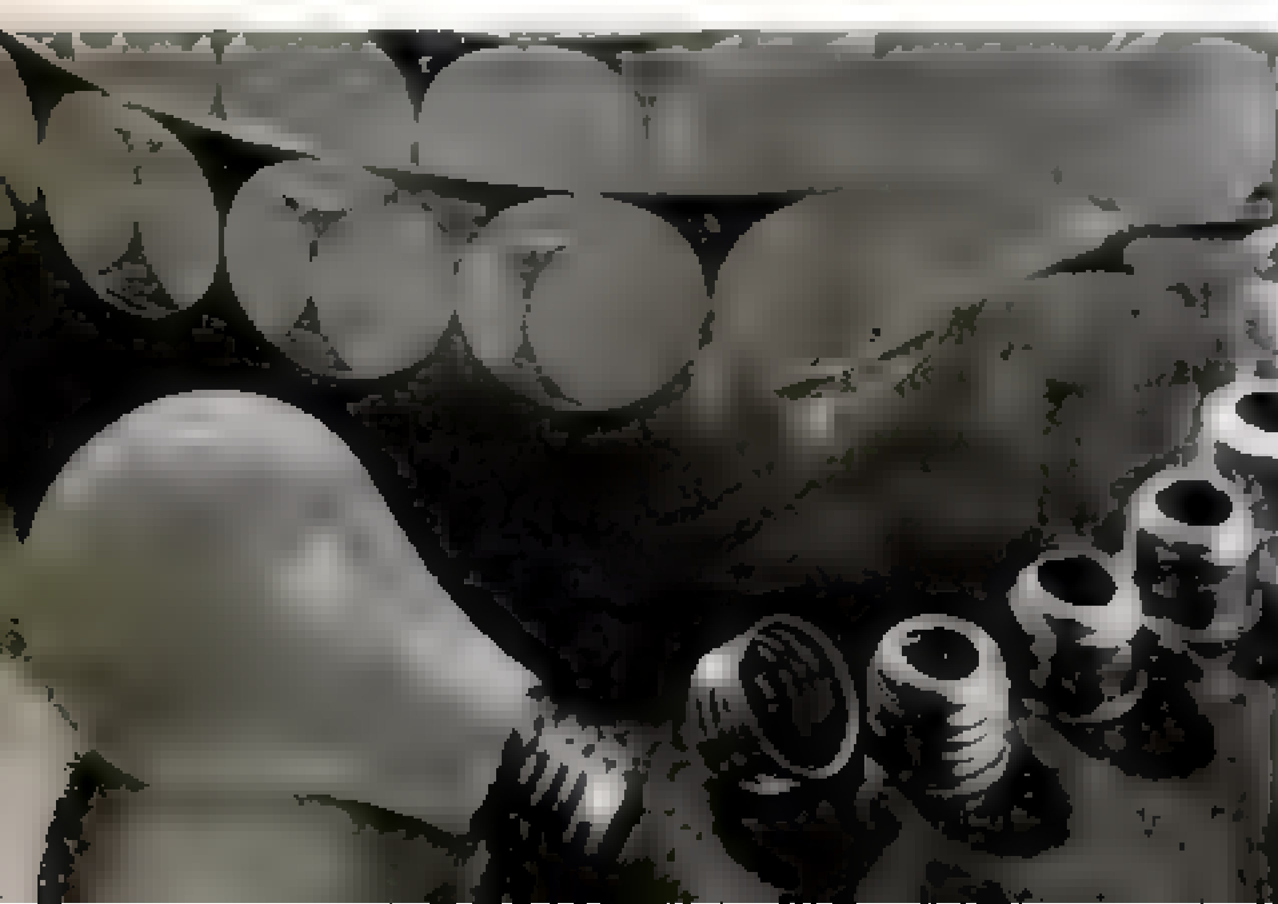
WINDOW SCREEN of plastic is a direct result of the shortage of copper, but it is proving a good idea in its own right. It is said to be as strong as copper, longer-wearing, and does not tarnish. The screening, woven from filaments of plastic instead of wire, is installed in the sash in the same manner as conventional wire screen

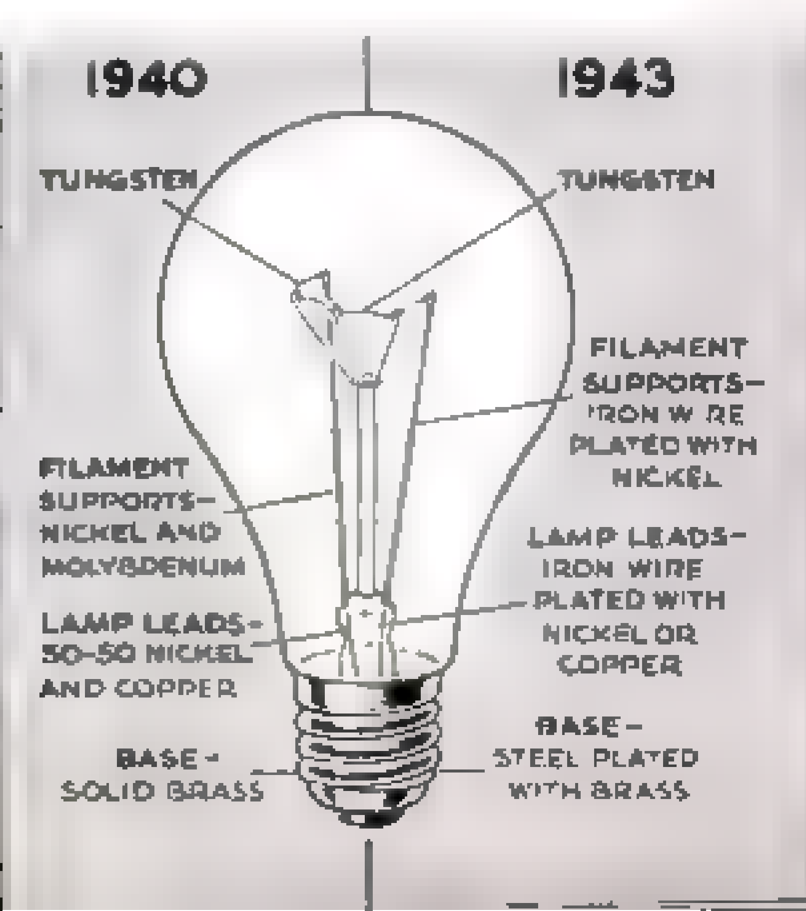
service. Similar bags are in use for cocoa, cookies, and certain chemicals.

Another vital packaging unit is the flexible tube, formerly made of almost pure tin, and now being replaced in part by a collapsible plastic tube, using no strategic materials and capable of being turned out in quantity with existing equipment.

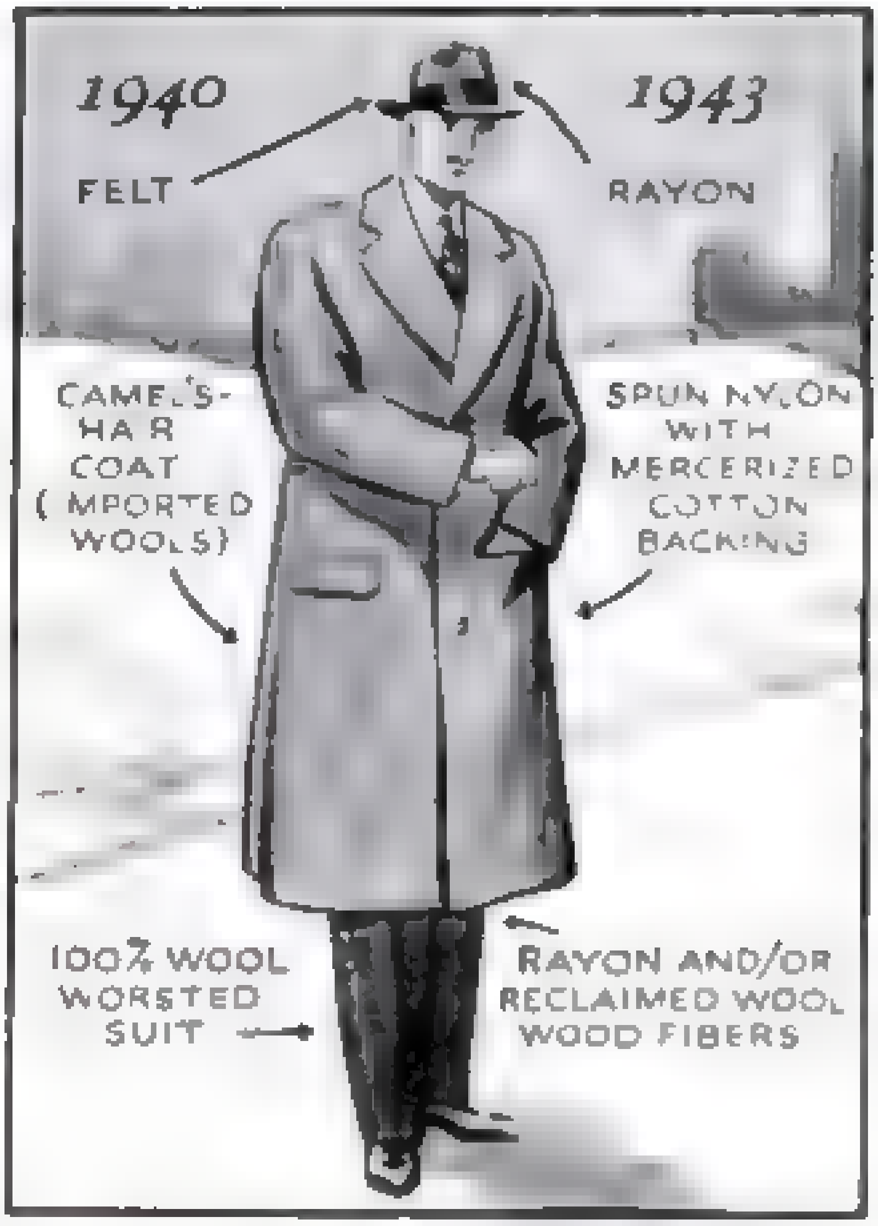
The tube, developed by Harry Waters, packaging expert, is reported to be satisfactory for grease-base items with low moisture content, including petroleum jellies, salves, greases, ointments, and some cosmetics. It rolls with almost the same ease as the vanishing tin tube, and is made of

LIGHT BULBS will be changed radically. The metal from which the bases are stamped, below, used to be solid brass. Now it is steel plated with brass. The drawing below shows other differences between the 1940 bulb and the one you will use in 1943. The tungsten filament is one part still unchanged

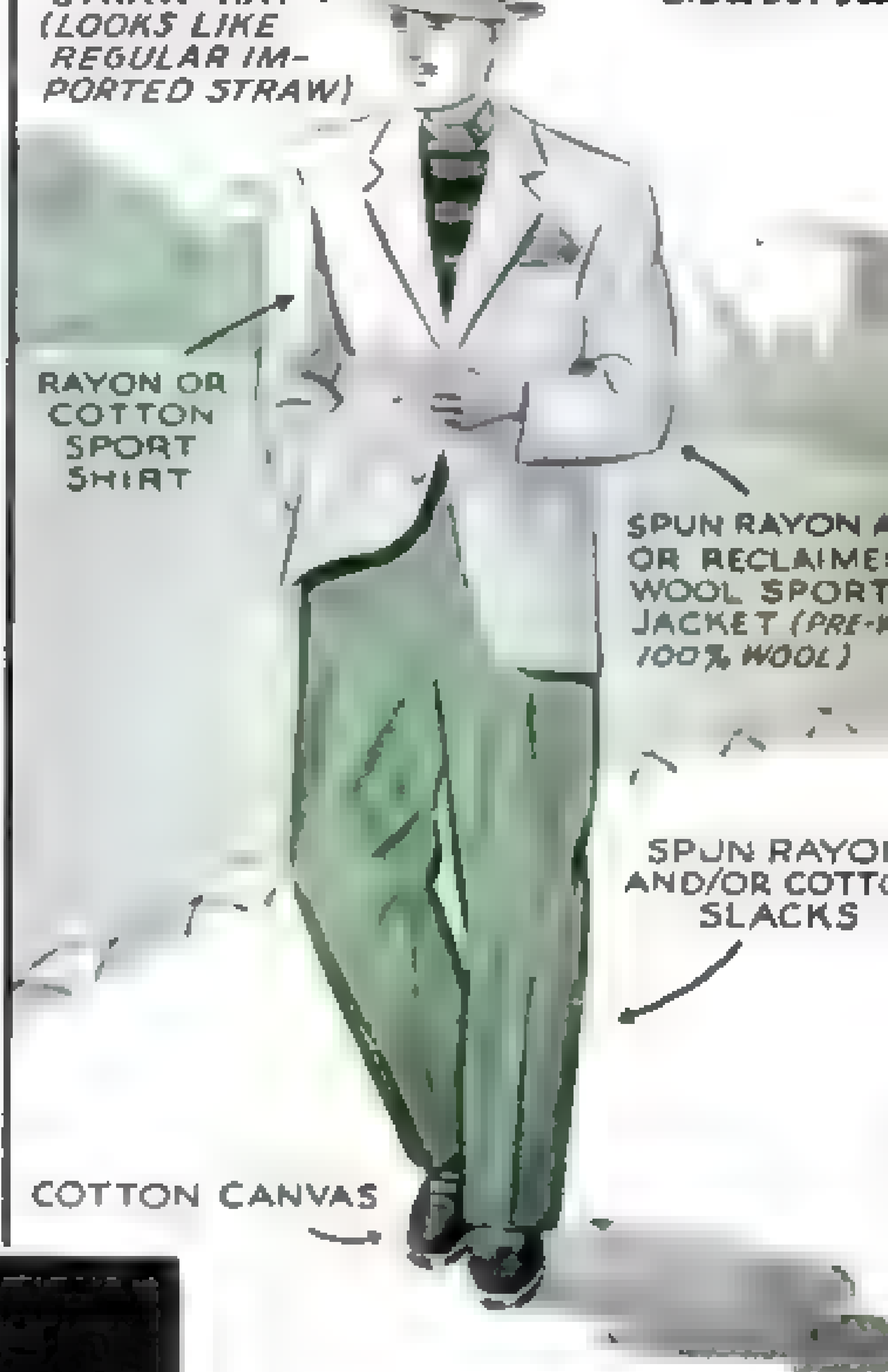


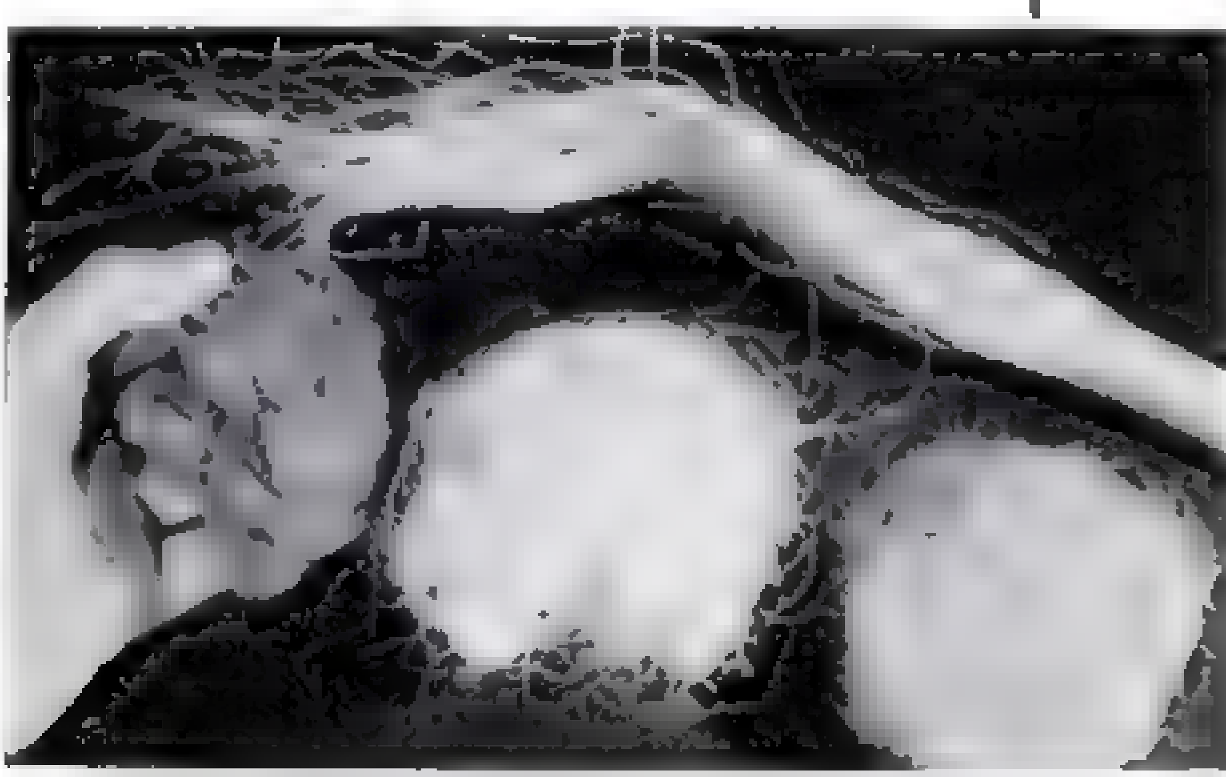


CLOTHING may look very much the same next year, but the materials will be different. Textile chemists have been busy developing new fabrics and materials to replace traditional wool leather, felt



Next Summer's Substitute Material





CORDAGE FIBERS are coming from strange sources. The balls shown in the photograph are (left to right) the fibers of redwood bark, yucca, and coarse flax. The long piece is istle fiber, from the Mexican century plant. They will replace hemp in rope, twine, and other cordage—and also sacking

a heavy seamless plastic, specially treated for flexibility. The tube will take printing, and can be made transparent or have a base color baked into it.

Factory lighting is an outstanding example of a field in which substantial savings of war materials are being achieved along with actual improvement in the efficiency and service of the equipment. A newly developed circuit for fluorescent lighting fixtures, with a special ballast control unit, saves nearly 50 percent of the critical materials formerly used in the control.

The new ballast unit controls four 100-watt flucrescent lamps instead of two, as at present. In only one of the nation's huge new aircraft plants, which is having more than 35,000 lamps installed, the total saving from this setup will amount to 23,275 pounds of copper, 80,960 pounds of iron and steel, and 8,250 pounds of aluminum.

Lamp bulbs for home use are still being made, but several changes have been put into effect on the actual construction process. The base, formerly made of solid brass, is

FOOD PACKAGING without the use of metal will bring changes to the pantry shelves. Cellophane linings offer a solution in the case of the products seen at the right, as well as for corn sirup, chili sauce, sauerkraut, other foods and drugs

GREASE DRUMS of plywood will enable the Standard Oil Company of Indiana to save enough steel annually to make about 40 tanks or 5,000 machine guns. Made of wooden sheets laminated together, the drums are lined with a chemical to keep grease from soaking in

OIL CONTAINERS of fiber board like the one shown below, release large tonnages of metal. A lining of impregnated paper makes it oil-proof. In addition to the saving of critical materials, the new container is considerably lighter than the one it replaces. This is another of the many new containers to be developed by Harry Waters

now formed of steel, plated with brass. Lamp leads, in the past made of a half-and-half alloy of nickel and copper, can be made of iron wire, plated with nickel and copper.

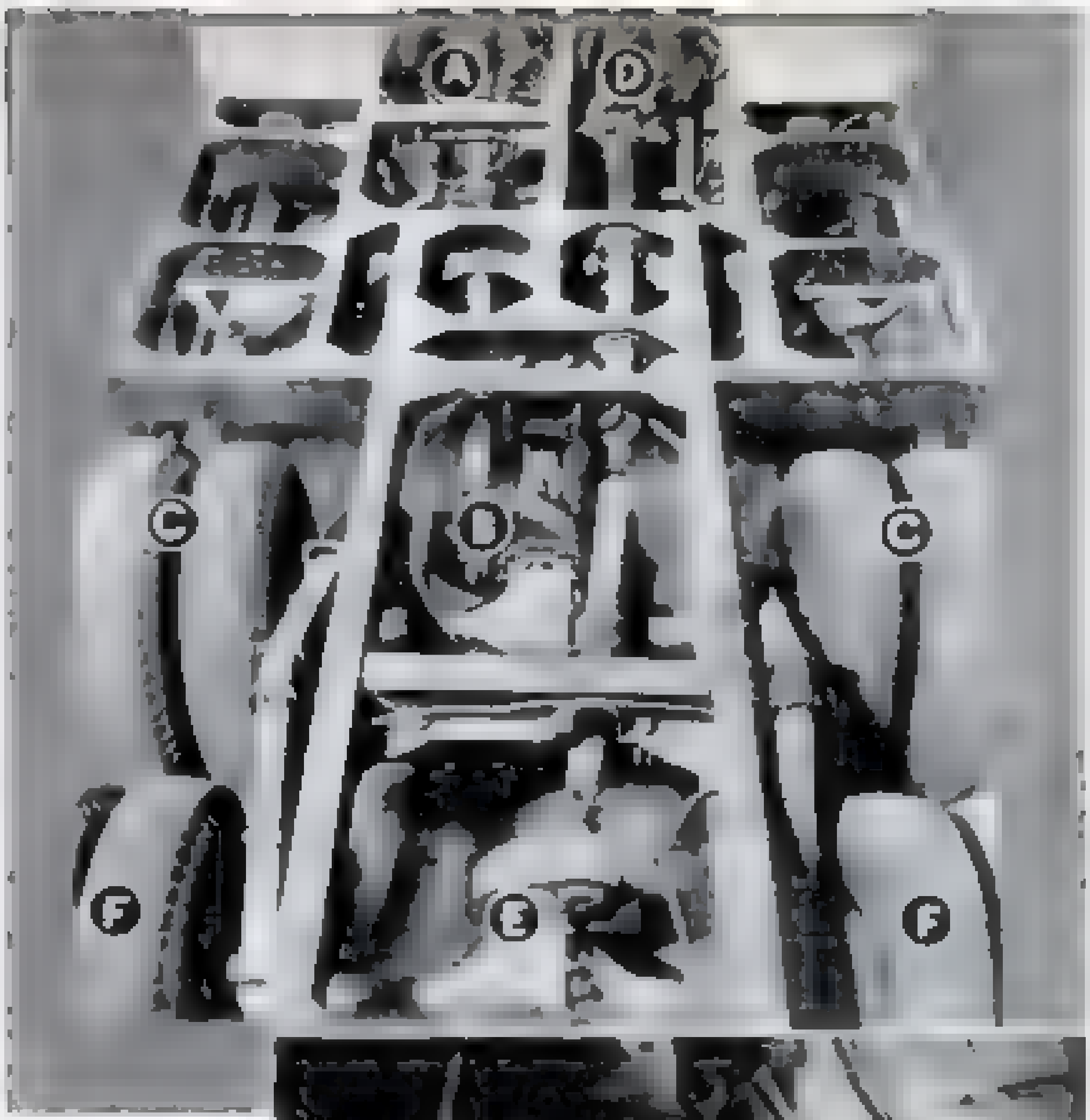
Similarly, iron wire plated with nickel alone has been found to be a satisfactory replacement for the old-type filament supports of nickel and valuable molybdenum. These plating processes make possible a saving of around 90 percent of the critical metals involved. Only the filament itself continues to be made of pure tungsten; no thoroughly workable replacement has been developed.

One of man's oldest and most useful materials—wood—also is stepping in to release metal for war. Wood is being used for bearings, bolts, nuts, and washers. The bearings, in particular, cost less than the metal they replace, and outwear it in many applications. Bearings of this type are usually made of selected portions of hard maple, grown in a few localities that have been found to produce the best trees for the purpose.

The new materials are in there punching for us while copper, steel, aluminum, and the other mainstays of our industrial team are busy playing the greater game of war. And it won't be surprising if a lot of the regulars find they will have to share their old assignments with the newcomers after the war.

How two engines are yoked up to drive the high-speed camera truck

Two Lincoln-Zephyr engines (A,.D) are mounted over the front axle as seen in the chassis view at right. Engine A has a drive shaft connected at B to the forward set of drive wheels (C,C). Engine D's drive shaft connects at E to the after set of drive wheels (F,F). Linkages connect the gearshift mechanisms and carburetors of the two engines for operation with one set of controls



Dual-Drive, Twin-Engine Camera Truck Films Movie Chases

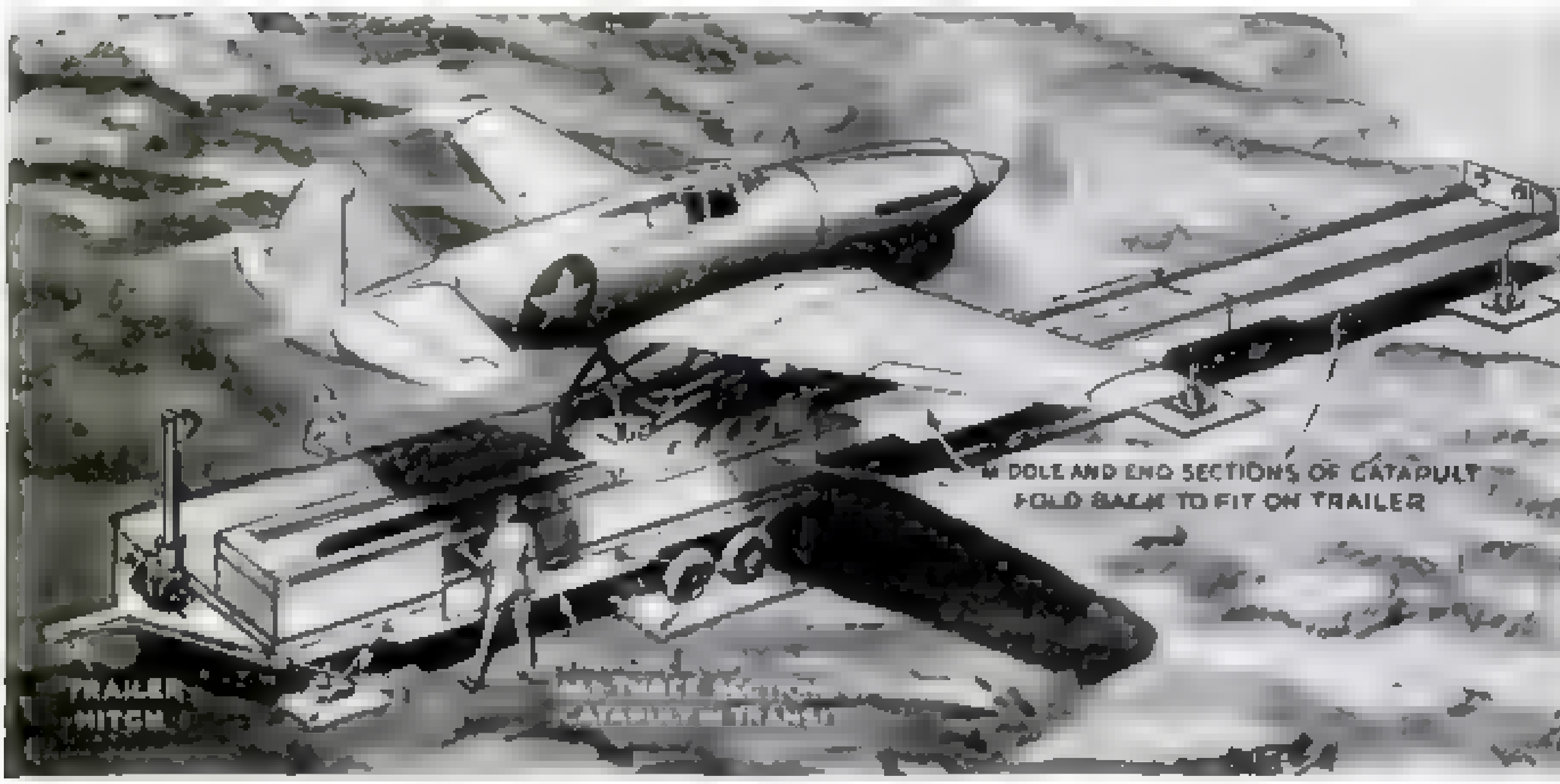
TWO automobile engines, mounted side by side and each connected by a separate drive shaft to four of the eight drive wheels, power a sturdy camera truck designed by C. L. Lootens for use by Republic Studios in filming chases and other outdoor scenes. Carrying both cameras and lights, the car is driven by two men. One steers and shifts gears while the other operates the accelerator in accordance with signals from the rear. Link mechanisms connect the two carburetors and gearboxes. The truck, which has made 80 miles an hour in tests, is believed to have military possibilities for carrying men and equipment, and towing guns.

Dual-control arrangement in the drivers' cab. One man steers and shifts gears and the other works the accelerator for speed

Filming a co-ed snake dance. The truck was designed primarily for making the chase scenes for Westerns and other films in which fast movement is important. It may have military value

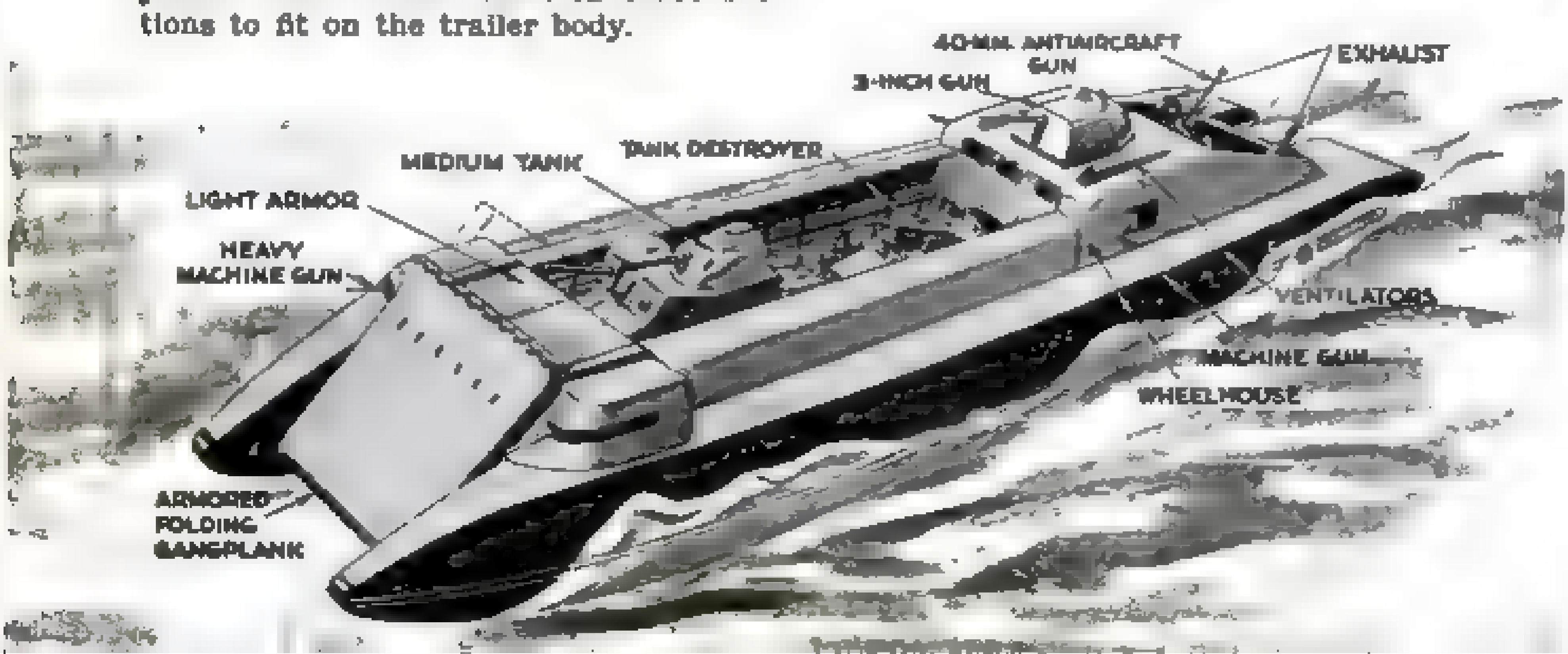
WAR IDEAS

BARGE AND AIRCRAFT CARRIER, this invasion ship, conceived by Jacques Martial and Robert C. Skull, industrial designers, has combination smashing power. Its deck holds 15 to 20 bombers and protecting fighters. Under the deck are tracks for five barges, and retrieving cranes. The ship mounts three triple 37-mm. antiaircraft guns, and can carry torpedo boats instead of barges.



TRAILER PLANE CATAPULTS, such as the invention depicted above, may be hauled into place by truck, and fighting planes launched by them from front-line positions where it would be impracticable to clear out even temporary flying fields. The runway consists of a jointed track which folds in three sections to fit on the trailer body.

LANDING BARGE. This open-top landing barge, capable of carrying a medium tank and a self-propelled 75-mm. gun, is heavily armed. Besides four heavy machine guns and an antiaircraft gun aft, it also mounts a 3-in. gun in a movable turret. The design is offered by Martial and Skull.

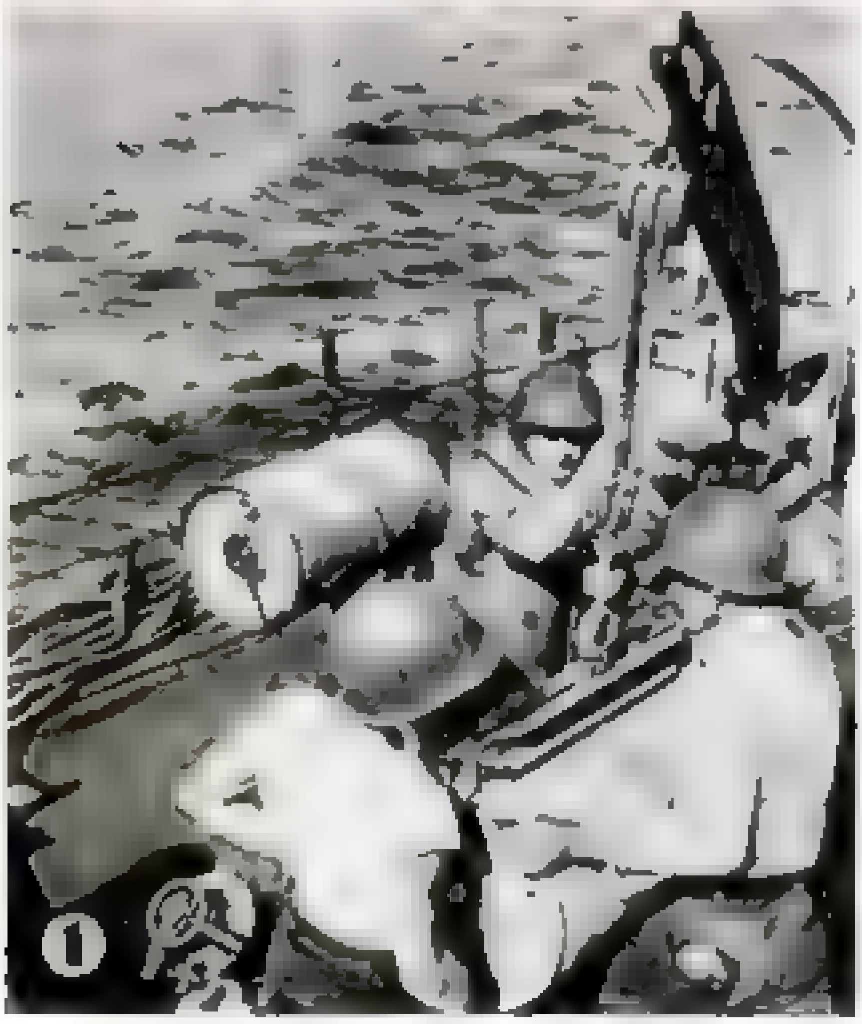


We Can Win the Battle of the Atlantic

New methods of convoy and patrol, with co-ordination of air and surface defense, are turning the tide in the struggle to keep open the Allied life line to Europe

DESPITE its destructive power and comparative invulnerability, the submarine will be defeated. The United States Navy will win the Battle of the Atlantic, and the task will be performed through teamwork—the co-ordination of all available methods of combatting the menace of the U-boat, and the continued enlargement and development of these methods. The Navy's plan of campaign against the submarine is essentially the same that proved successful in the First World War; it calls for constant bombing of overseas bases and unremitting attack upon the U-boats prowling our waters. Ultimately the submarine will be overwhelmed by the crushing strength of enormous fleets of

Air and surface craft work together to guard our convoys. Here a bomber has dropped depth charges where a lurking sub was sighted, while destroyers wheel out of formation to hurl their own "ashcans"

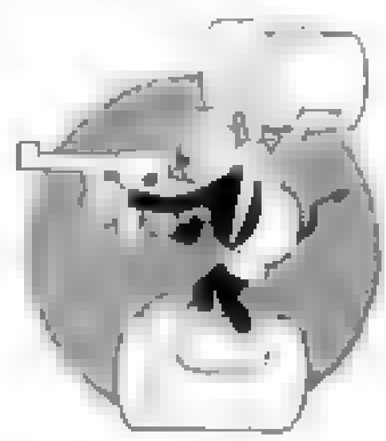


Depth Charges Are Poison to U-Boats

On the heaving deck of an escort vessel (1), depth charges are carefully loaded onto the branching arms of a "Y gun." To lay down an explosion pattern around the suspected hiding place of a U-boat, a blast of compressed air sends the "ashcans" tumbling through the air (2) to a distance of 100 to 200 yards on either side of the speeding craft. As the charges sink in the water, hydrostatic pressure sets them off at a predetermined depth ranging from 30 to 100 feet and the explosions churn the water beside the ship's wake (3). Blasts set up tremendous water pressure which is felt within a radius of 250 feet. If one of these charges explodes within 50 feet of a submerged U-boat, it will crumple its plates for an almost certain kill

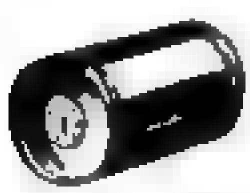
cargo ships convoyed by swarms of heavily armed destroyers, corvettes, and other escort vessels, by tens of thousands of bombs and depth charges, and by thousands of airplanes, blimps, and patrol boats which will leave unwatched no stretch of sea adjacent to our coasts. Whether the victory is won soon or late will depend upon the speed with which equipment can be built and crews trained to operate it.

Several factors, aside from lengthened lines of communication and vastly expanded operational areas, make the task of defeating the submarine more difficult than it was in the last war. One is a shortage of destroyers, natural enemies of the U-boats. The destroyer strength of the United Nations is less than one third as great as that of Great Britain alone in 1917. Another is the increased number of U-boats. During the First World War no more than six submarines ever operated in American waters at any one time, while throughout the summer of 1942 between 30 and 40 were continually on the prowl in the western Atlantic from Canada to the Carribbean Sea. A third factor is that the submarines with which the Nazis are now preying upon American shipping are the most efficient undersea raiders that German engineers have ever constructed.

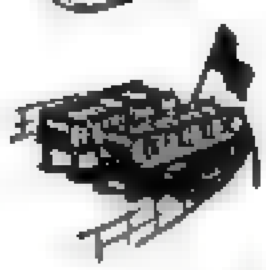


Most of these boats are comparatively small, of about 500 tons displacement, but they are double-hulled for additional strength, and greater fuel-carrying capacity —ballast tanks are filled with oil—gives them a cruising range of from 10,000 to 15,000 miles, with a speed of 18 to 20 knots on the surface. They can submerge to 400 feet, a third deeper than the standard limit, and can disappear in a crash dive in 27 seconds. They are equipped with listening devices superior to anything the Germans have ever used before. They carry crews of

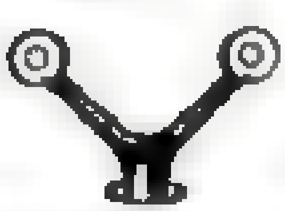
Here Is the Deadly "Ashcan" —and How It Is Delivered



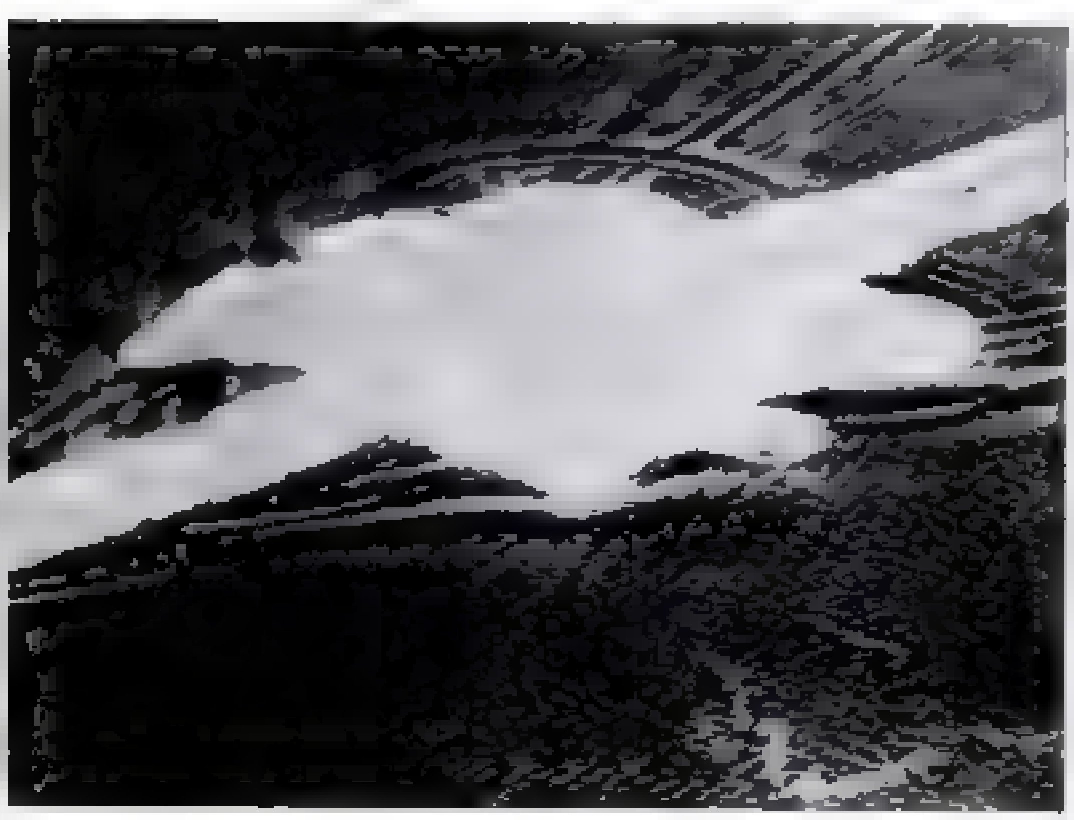
DEPTH CHARGE, a metal can packed with 600 pounds of TNT, is dropped from a



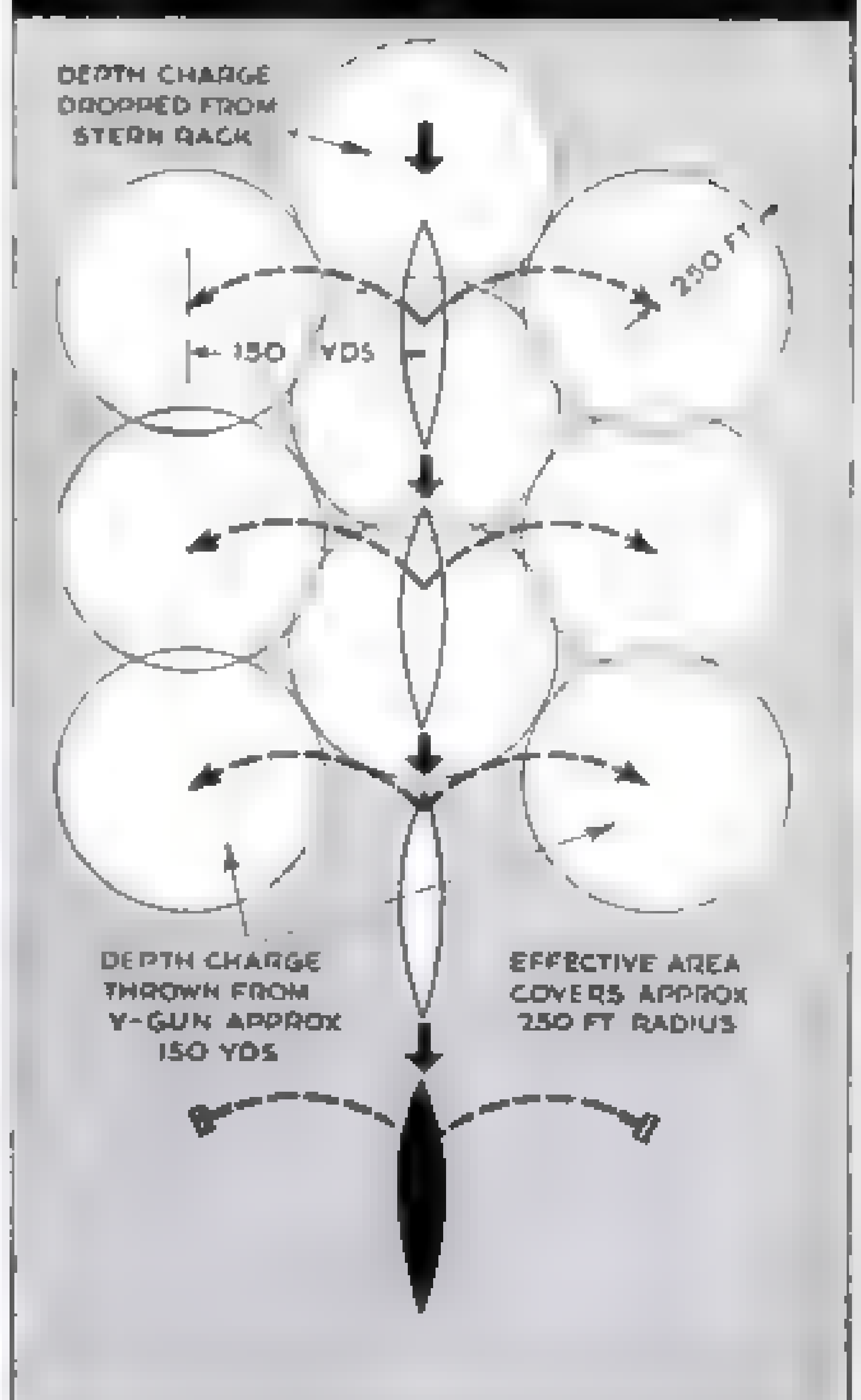
STERN RACK, which lets it roll into the wake of the ship. Or, it is fired from a



Y GUN. Here, compressed air hurls it over the side for wider dispersal of fire



DEPTH-CHARGE BLAST PATTERNS WEAVE A NET OF DESTRUCTION



50 men, and are armed with machine guns, four-inch deck guns, and a dozen torpedoes, which can be fired without raising the periscope. Recently the Nazis have been doing great damage with a new electric torpedo which, since it uses no compressed air, leaves no wake, so that the direction from which it is fired cannot be determined. Such a torpedo gives no warning.

Some U-boats are fitted with mine-laying apparatus, with which they have been planting in American waters a new type of mine which is both acoustical and magnetic; it can be set off by the sound of a ship's propellers or by the steel hull. Moreover, the mechanism can be adjusted to explode the mine upon any of a series of interruptions, so that half a dozen ships might pass over it safely and the seventh be destroyed. This weapon has greatly increased the difficulties encountered in sweeping the coastal sea lanes.

The Navy classifies its activities against the U-boat as active defense and passive defense. The latter term includes mine fields, booms, and nets designed to protect harbors; artificial anchorages formed by mine fields in shallow waters, into which convoys and single ships can be withdrawn at night; and camouflage. The most effective form of camouflage is that known as dazzle painting, intended not to make the ship partially invisible, but to deceive the U-boat commander as to her speed and direction. Properly applied, dazzle painting can give the illusion that a ship is sailing at right angles to her real course, or even backward, and that she is traveling at twice her real speed.

Active defense means attack, and the term embodies all the methods with which the Navy hopes to defeat the U-boat. Important among them are convoying with destroyers, corvettes, the new 173-foot PC boats, and converted yachts; offshore and deep-sea patrol by military and naval airplanes and blimps; scouting patrols by

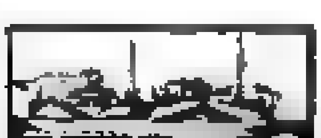
THESE ARE THE WEAPONS THAT ARE WINNING THE BATTLE

War on the submarine is divided tactically into two classifications: passive defense and active defense. The former includes all means of placing obstacles and dangers in the way of the U-boats, and hampering them in their operations. The latter, which is really attack, actually goes after them

PASSIVE DEFENSE

MINES, sown in fields in the approaches to important harbors and estuaries, present a constant hazard to prowling subs. Mine fields can also be used in shallow waters to create artificial anchorages in which convoys or single ships can take refuge at night. Openings in mine fields are secret, and vessels are piloted through them

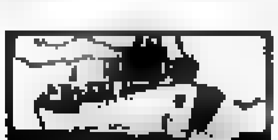
NETS AND BOOMS stretched across the mouths of harbors keep U-boats from sneaking in to ravage anchored shipping like wolves in a sheepfold. Woven of heavy metal cab-e, the nets are supported by floats or booms and tethered to the shore. Gates tended by auxiliary vessels are swung open to let vessels or convoys through



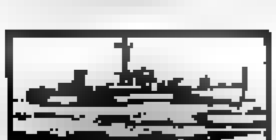
CAMOUFLAGE is applied to ships to fool the marauders. The most effective form is "dazzle painting," which is calculated not so much to reduce visibility as to give the U-boat commander the wrong idea of the vessel's speed and direction—factors which he must know within reasonable limits if he is to score a hit with a torpedo

ACTIVE DEFENSE

DESTROYERS are natural foes of the submarine because of their speed, armor, and hitting power



CORVETTES, specially built for convoy work, are more easily replaced than costly destroyers



PC BOATS are fast, unarmored sub-chasers. The latest type is being built to 173-foot length

PLANES spot subs from the air, report location to surface craft, use bombs and depth charges

BLIMPS are specially valuable for hunting U-boats because they can hover almost motionless aloft

CIVILIAN PLANES help in the work of scouting and observation, carry no bombs or depth charges

LISTENING DEVICES of both hydrophone and supersonic types warn of the U-boat's approach

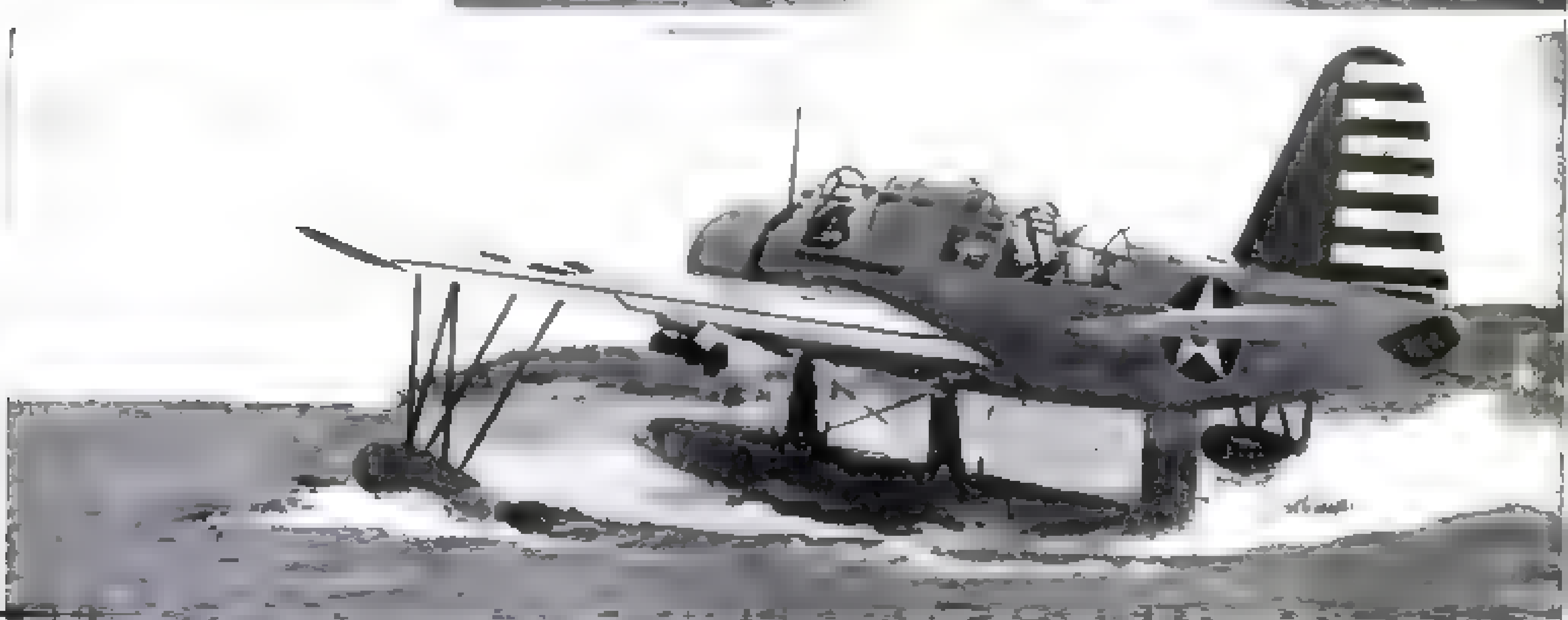
Q BOATS, decoy merchantmen with concealed guns, trap unwary subs that surface for the kill

civilian planes; the use of new and highly secret detecting devices, some of which can locate a surface vessel or a submarine eight to ten miles away; and the use of Q boats, decoy merchant ships equipped with hidden guns manned by trained naval crews. All boats, blimps, and planes used in convoy or patrol work, except the civilian planes, carry bombs and depth charges, in addition to varying numbers of machine guns, 20-millimeter guns, and four-inch naval rifles. The depth charge used by the blimps and the smaller ships contain 300 pounds of TNT, but the amount of explosive in those carried by destroyers, corvettes, and PC boats has been increased to 600 pounds. They are discharged from stern racks, and from "Y guns" which throw them over the sides of the boat and

PC boats like this are made to order for short-range escort and patrol work. Shallow in draft, heavily armed, and fast, they play an important part in the "killer group" technique shown on the next page

Gun crews for merchantmen also help to break up the undersea blockade. This is a typical installation on a cargo ship. The crews manning these guns have distinguished themselves in many encounters

An observation plane, below, takes off on a hunting trip. In addition to radioing the location of any submarine it sights, it can make things hot for Jerry with its own supply of bombs or depth charges



from 100 to 200 yards away. The Y gun is more effective than the stern rack because it lessens the danger of a ship being damaged by the explosion of its own depth charge, and also because it makes possible a greater dispersal of fire by putting more "ashcans," into a given target area.

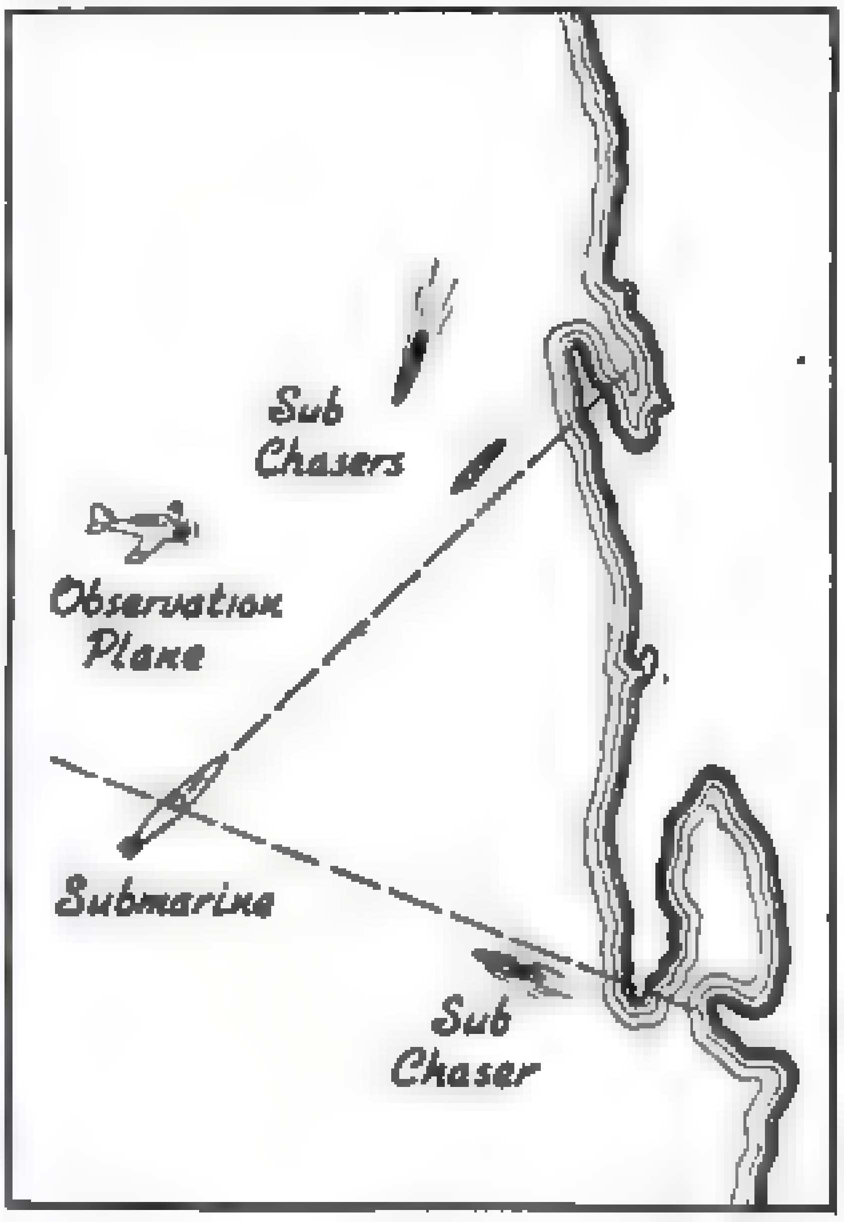
An entirely new method of active defense, known as the "killer group," is being organized by the Navy, and will be put into effect when enough ships are available. This will involve first of all the fitting out of temporary bases along the coast from 50 to 100 miles apart. In each of these harbors will be stationed from one to three shallow-draft, heavily armed, very fast sub-chasers, probably of the 110-foot type, which will be kept ready to sail at a moment's notice. Patrol planes and blimps at sea, sighting a submarine, will report its location by radio, whereupon the killer boats will rush from their harbors, converge upon the area, and remain there until the submarine has been hunted down and destroyed.

Of all the methods now actively employed to combat the submarine, the convoy system and the blimp have proved most effective. The work of the blimp, in fact, has so far exceeded expectations that the Navy has embarked upon a building program which will add more than 60 of these useful craft to the eight already in service. Larger sizes are also planned. All blimps carry machine guns and depth charges, and are also equipped with listening devices.

The blimp has proved to be extremely valuable in convoy work in areas where enemy fighter planes cannot operate, and within the limits of its cruising range, but its most effective work has been done on lone scouting and hunting expeditions. Its most valuable asset as a submarine hunter is its ability to hover; it can stop almost dead in the air, in consequence of which its depth charges can be dropped with extreme accuracy. Also, the blimp can sit and wait for its prey like a cat at a rat hole; on several occasions blimps have been known to hover for from one to six hours over a spot where there was reason to believe a submarine might be submerged. When the U-boat finally came to the surface it was promptly depth-charged and destroyed.

Convoying was the final answer to the

A "KILLER GROUP" IN ACTION. This is our artist's conception of a new anti-submarine technique being developed. Patrol planes and blimps sight submarines and report their position to temporary bases on the nearby coast. From these, fast, heavily armed killer boats dash out, converging on the scene. As many as six should be on the spot in an hour or two

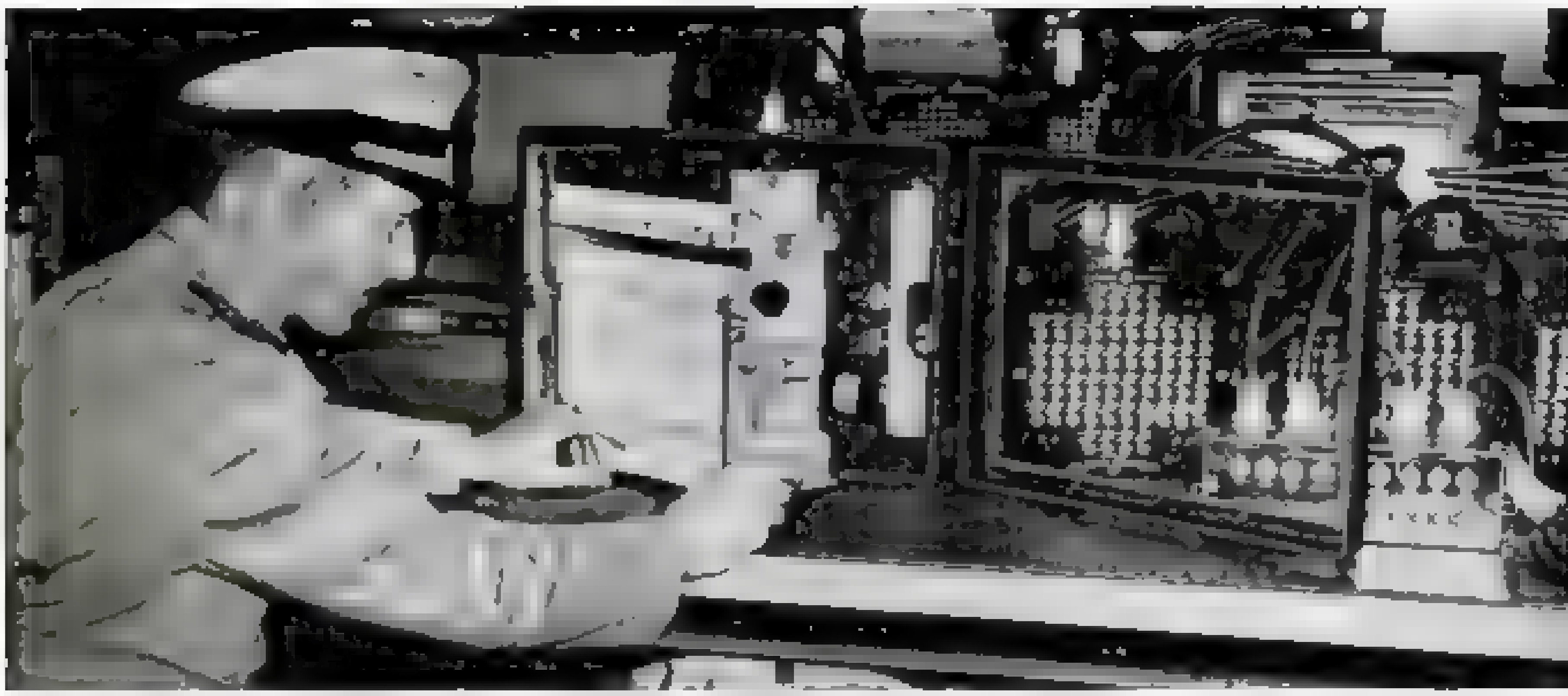


submarine menace in the First World War, and it is likely that, employed in close co-operation with other methods of keeping the U-boats at bay, it will ultimately be the answer in this war also. Naval officers point to the fact that during the first four months in which coastal convoys were operated in the western Atlantic, only four out of 2,000 convoyed ships were lost; and to the further fact that while several recent troop convoys to England and Ireland were attacked, in no case did a submarine get close enough to a troopship to fire a torpedo.

Various factors enter into the successful operation of a convoy. The number of escort vessels is of prime importance, for the greater the number of destroyers and corvettes the greater the safety of the convoy. The crews of the merchant ships must be alert and courageous, and their captains must be willing and able to obey orders instantly and intelligently. So rigidly are the orders of the commanding officer of convoying warships enforced that the ship's captain who refuses to obey is compelled to remove his vessel from the convoy.

The ideal convoy, of course, is one in which every ship possesses the same top speed, but such a condition is probably unattainable. In consequence, the speed of a convoy is limited to the speed of the slowest ship. When a convoy leaves port the ships are formed into line, each with a number. All radios except the official instrument are sealed, and all signaling is done by flag, blinker, or whistle. Each ship is completely blacked out at night. Overhead and far out to sea roar the bombers and patrol planes, while destroyers and corvettes race up and down on each side of the convoy and in the lanes between the lines of ships. Ahead and behind are other warships, gun crews on the alert and depth charges ready to be dropped or fired overboard from the Y guns.

It is probable that there is some loss of efficiency in the convoy as compared with the turn-around sailing by single ships, but naval officers say that this loss would not exceed 20 to 30 percent. In the final analysis, the loss might not appear at all, for while time is lost in forming the convoy and shepherding it across the ocean, the system saves valuable cargoes and even more valuable ships.—HERBERT ASBURY.



Electronic Device Records Plane's Behavior on Test Flight

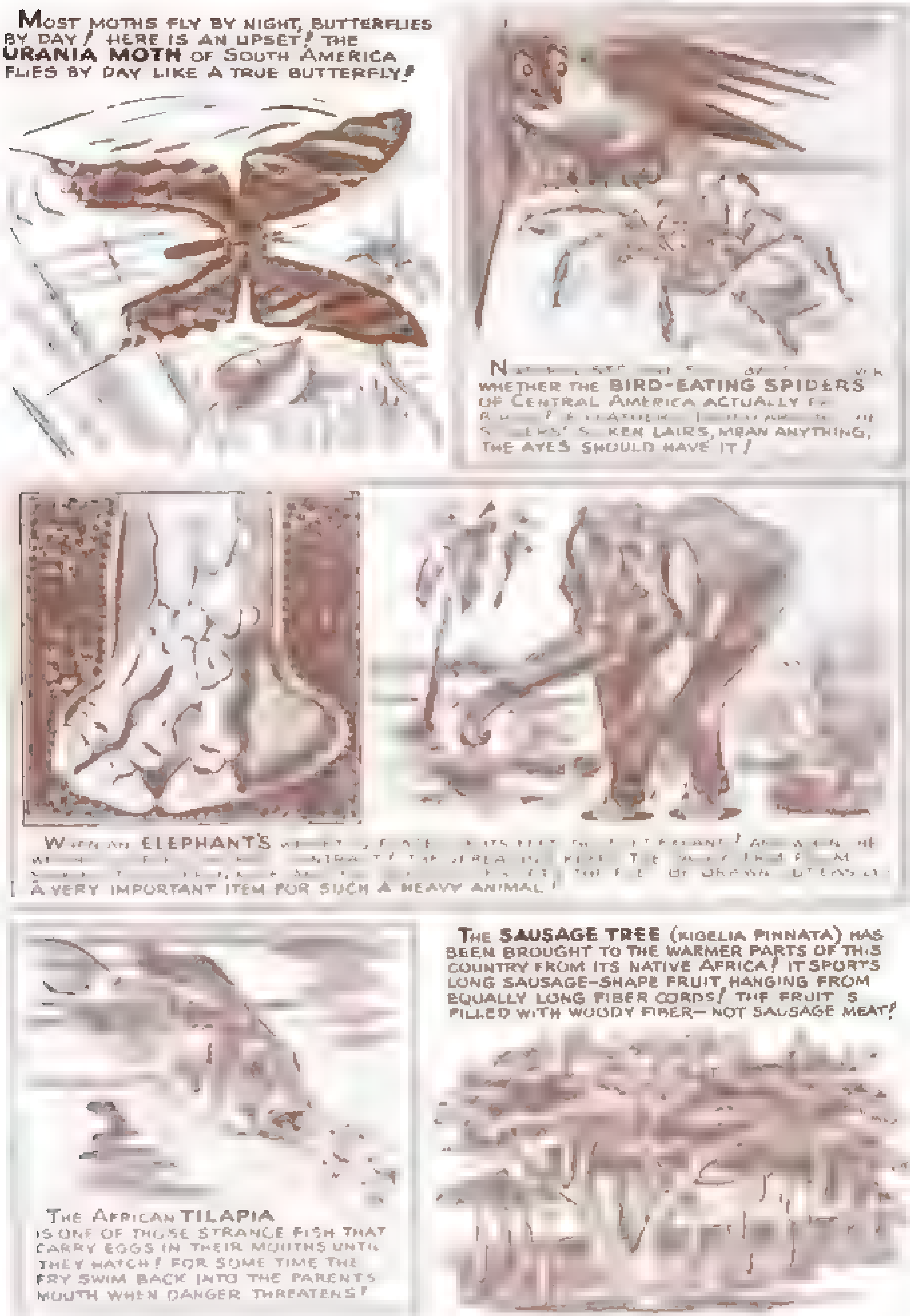
NOW standardized and perfected for Government use, an electrical recorder registers more data on a plane's behavior during a test flight than could be observed by a whole crew of engineers, and can make as many as 144 readings every three or four minutes. In a trial aboard the world's biggest plane, the Douglas B-19, it constantly measured the temperatures of all 72 motor cylinders, the temperatures of carburetors, exhausts, and oil lines, and pressures on wing struts, bulkheads, and tail surfaces. Because of its compactness, it serves admirably for charting the performance of single-place pursuit ships, where carrying along test engineers besides the pilot would be out of the question. Desired data are automatically printed during flight on a moving strip of paper, shown being examined above.

"Bubblfil" to Replace Unavailable Kapok in Life Jackets, Rafts

BY BLOWING air bubbles in viscose thread, Du Pont research workers have developed a new war product called Bubblfil, to replace unavailable kapok from Java. In life jackets or rafts it supports 20 to 30 times its own weight, equaling the buoyancy of kapok and losing it less rapidly with prolonged immersion. Less combustible, it cannot be ignited by a tracer bullet. Substituted for scarce sponge rubber in the pontons of temporary bridges, it keeps them floating when riddled with bullet holes. At right is a magnified view of the air bubbles blown into viscose thread.

Un-Natural History

BY *Gus Mager*



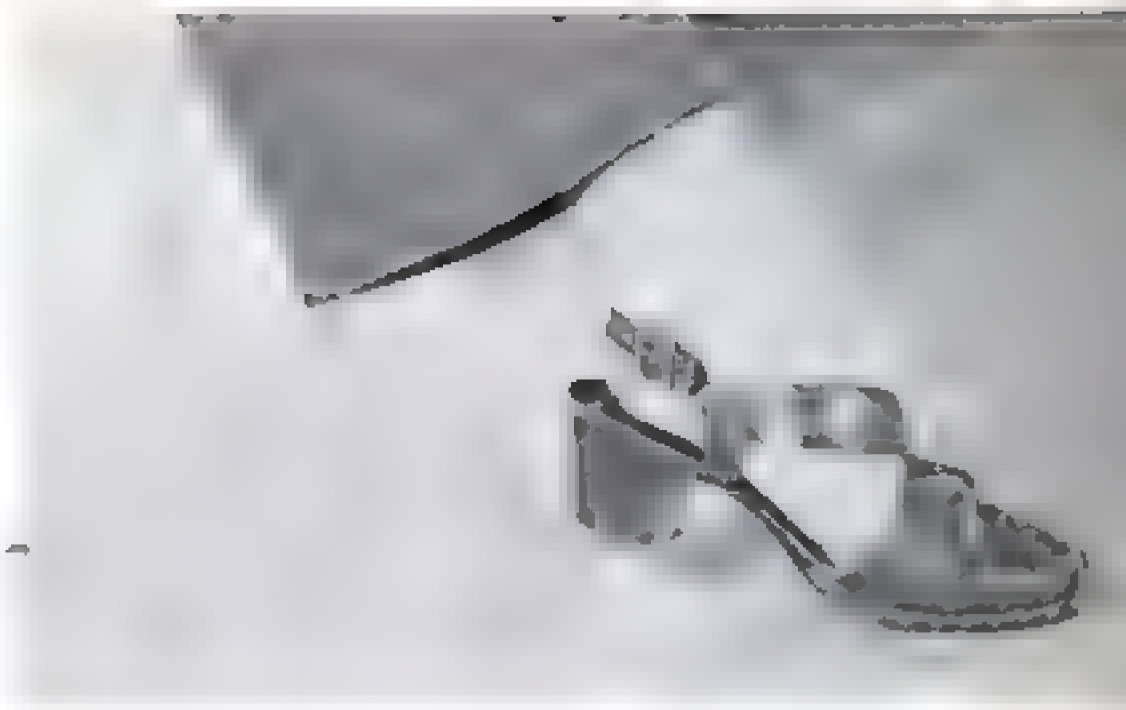
TEST YOUR POSTURE by standing with your back to a wall. Your head, shoulders, buttocks, calves, and heels should all touch the wall. Make this test frequently to correct bad habits of wrong standing

HOW YOU CAN

Step Lively

FOOT POSITION is tested by standing with the feet together like this. When you walk, move the feet forward and keep them in the same line, pointing ahead

IT'S fun to walk, if you haven't forgotten how. Fun or not, you may as well get used to the idea of getting from here to there under your own steam, for you're going to be self-propelling yourself more and more for the duration of the war. As in any other endeavor, there's at least one right and many wrong ways. On these pages, two well-known young movie players, Donald O'Connor and Gloria Jean, show you the proper way to walk. Their demonstration is based upon a technique worked out by Dr. Leon J. Richardson, whose booklet, "Care and Use of the Feet," adopted by the Army, revolutionized walking by American soldiers. Follow these suggestions, and you'll cover the ground with less fatigue—and you'll enjoy walking as never before!



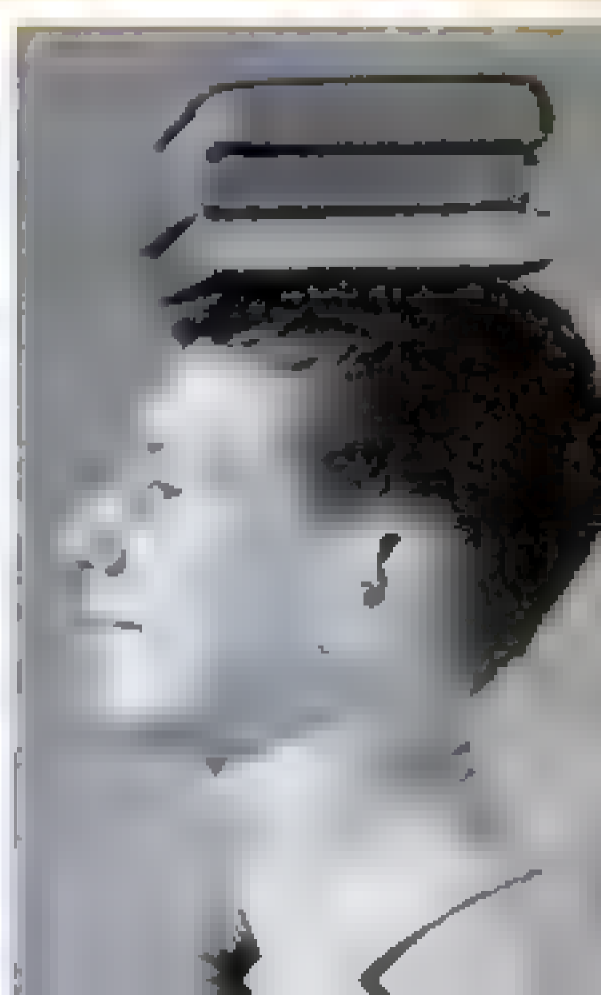
WRONG. Don't bring your foot down toe first. Lots of people walk this way, but it tires you rapidly because it throws the weight of the body on the ball of the foot

START WALKING. Step forward vigorously keeping the toes pointed straight forward and swinging the hands in a small arc. Develop rhythm, rotating the shoulders to the left as the hips rotate to the right

RIGHT. This is the proper way to bring the foot down with the heel touching a little before the ball of the foot. Wear shoes that are wide enough to allow your toes to do the work for which nature intended them. Swing the leg from the hip instead of merely kicking from the knee

EXERCISES. If your muscles are weak from too much riding or from incorrect walking, try the daily exercise illustrated below. Every morning rise on your toes 10 or 12 times. Spread the toes to make the little fellow do his share. Toe in slightly to bring foot and leg muscles into play. Arch is strengthened

HEADWORK. Balance a few books on your head and take some steps. This shows how to hold the head



Press Jams Scrapped Auto into Two-Foot Space

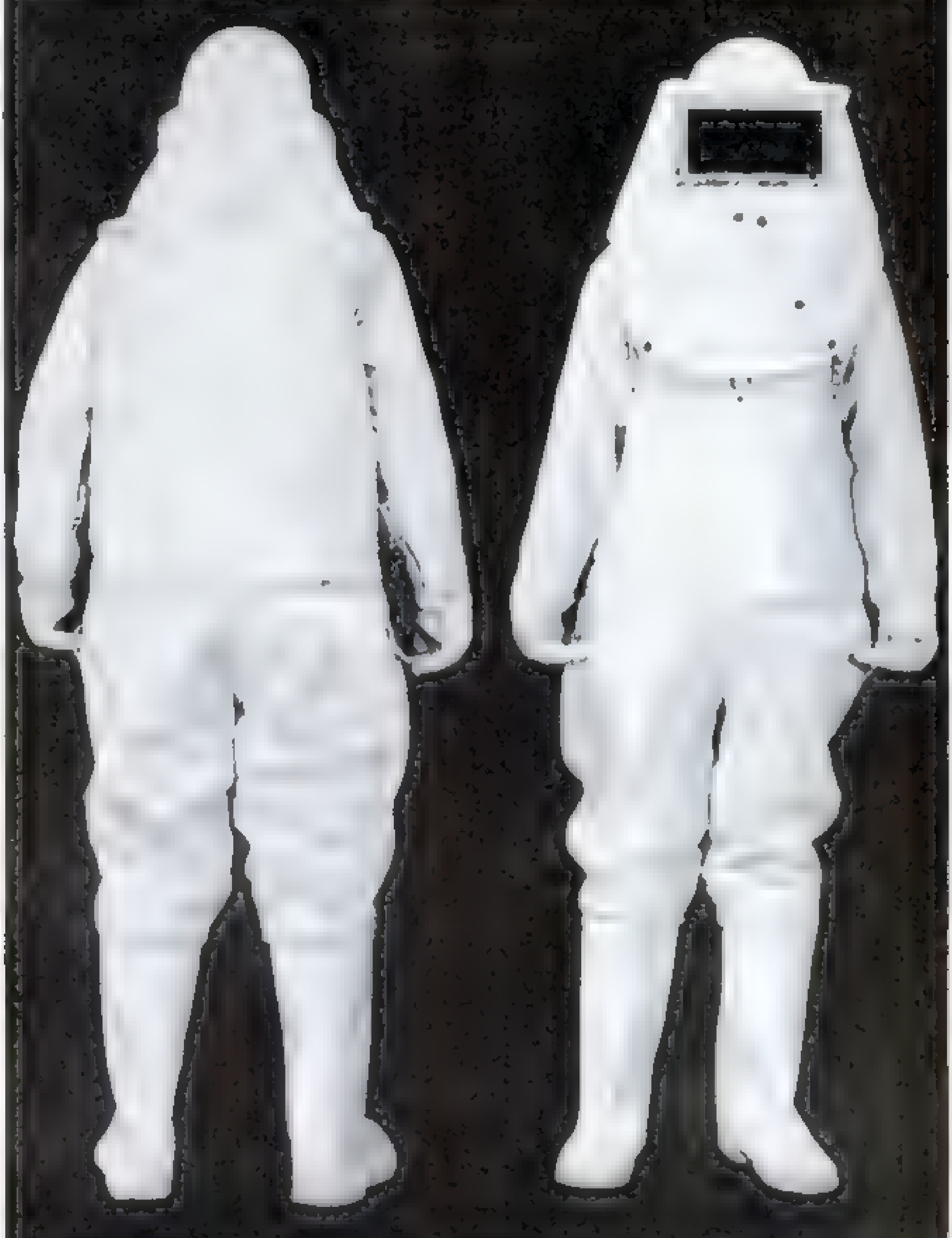
ANY man who has found it hard to squeeze his own belongings into a traveling bag will envy the efficiency of a hydraulic press that crushes a whole automobile body into scarcely greater space. In a dozen smashing blows, it makes the steel shell of a worn-out sedan unrecognizable. One plunger pushes in the sides, a second shoves forward from the rear, and a third jams the floor against the top. The result is a bundle measuring 12 by 18 by 24 inches and consisting of 70 percent solid metal. Each day the outfit salvages 65 tons of scrap, which is rushed to southern California mills for making new steel.

Shaped like a blunt-nosed wedge of pie, and fitted with rams that compress the four sides, the mighty machine and its battery of controls were designed and built by Jack Gantz and placed in service by Jerome Williams, both of Los Angeles, Calif. A crane and electromagnet feed the press and remove the finished bundles. During its first year of operation, the machine has "packaged" about 5,000 car bodies and 16,000 tons of other scrap iron and steel.

This giant crane and electromagnet pick up an entire sedan body to be fed into the hydraulic press for scrap. It easily handles 300 pounds of loose clippings or one 600-pound auto body

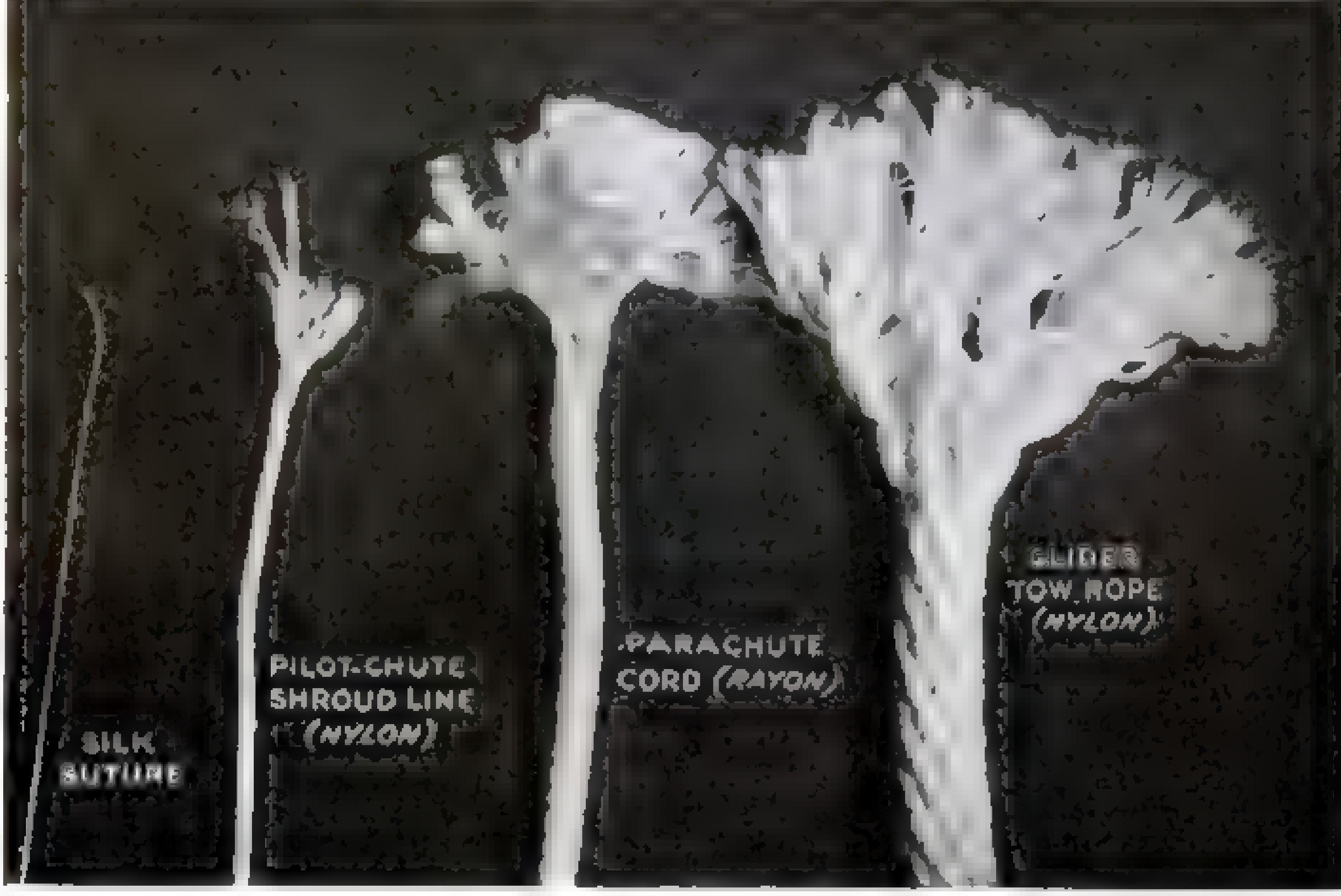
After 12 smashing blows, the sedan is reduced to suitcase size. Two pumps operate the rams, one forcing 75 gallons of oil a minute, the other 150, to create great pressure. Below, the magnet picks up the compact bundle for delivery to a steel mill

Lighter Suits Aid Airfield Firemen



FIRE-FIGHTING SUITS made out of a new lightweight asbestos fabric called "asbeston" are now part of the equipment for aircraft ground crews and other divisions of the armed forces. Less bulky and more flexible than older types, the new asbeston suits do not restrict the wearer's movements, while the molded bootlike leg coverings make walking easier.

Fishlines to 'Chute Shrouds



Types of braided cord used in war work. They are made of silk, rayon, and Nylon, and range in use from surgical sutures to lines for towing gliders

TWISTED INTO STOUT LINES, SILK, NYLON, RAYON, AND COTTON DO MULTIPLE DUTY FOR OUR FIGHTING FORCES

ROPES for nonstop air-mail pickup and twine for the making of ropes for towing gliders, shroud lines for pilot 'chutes, and silk sutures for surgical use have become the major products of an eastern factory that once turned out fishing line and other articles for sporting use and other peacetime pursuits.

Because the art of manufacturing cordage follows long-established methods, regardless of eventual use, the Ashaway Line and Twine Manufacturing Company have been able to convert their plant to war work without any radical changes in their existing machinery. In every case, the task consists of building up slender threads of suitable material into cord of specified diameter and tensile strength. These threads may be twisted, braided, or both. Most frequently the product combines a twisted filler and a braided cover.

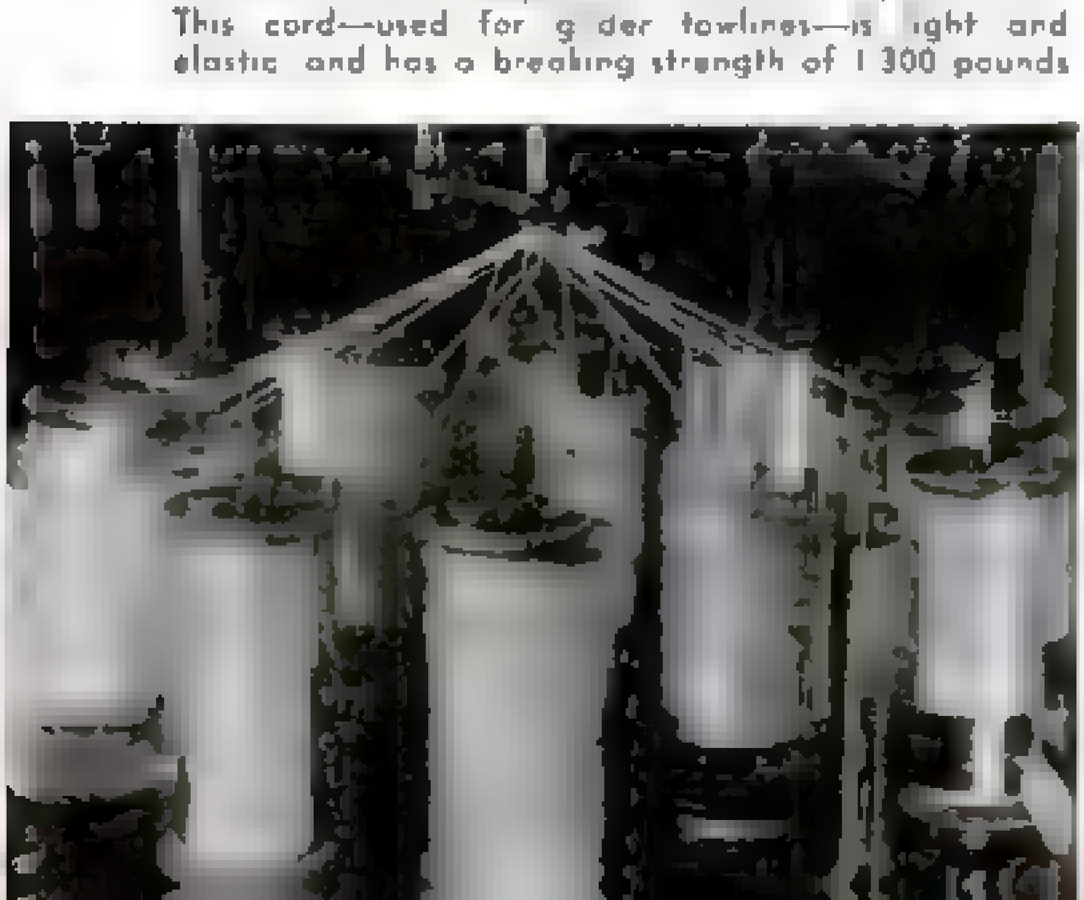
Large twisting machines, used before the war in making silk and Nylon fishlines, now twist and spin Nylon threads for the filling and cover of parachute shroud lines. A product of this type having a cover over a filler is known to the cordage trade as "balanced cord."

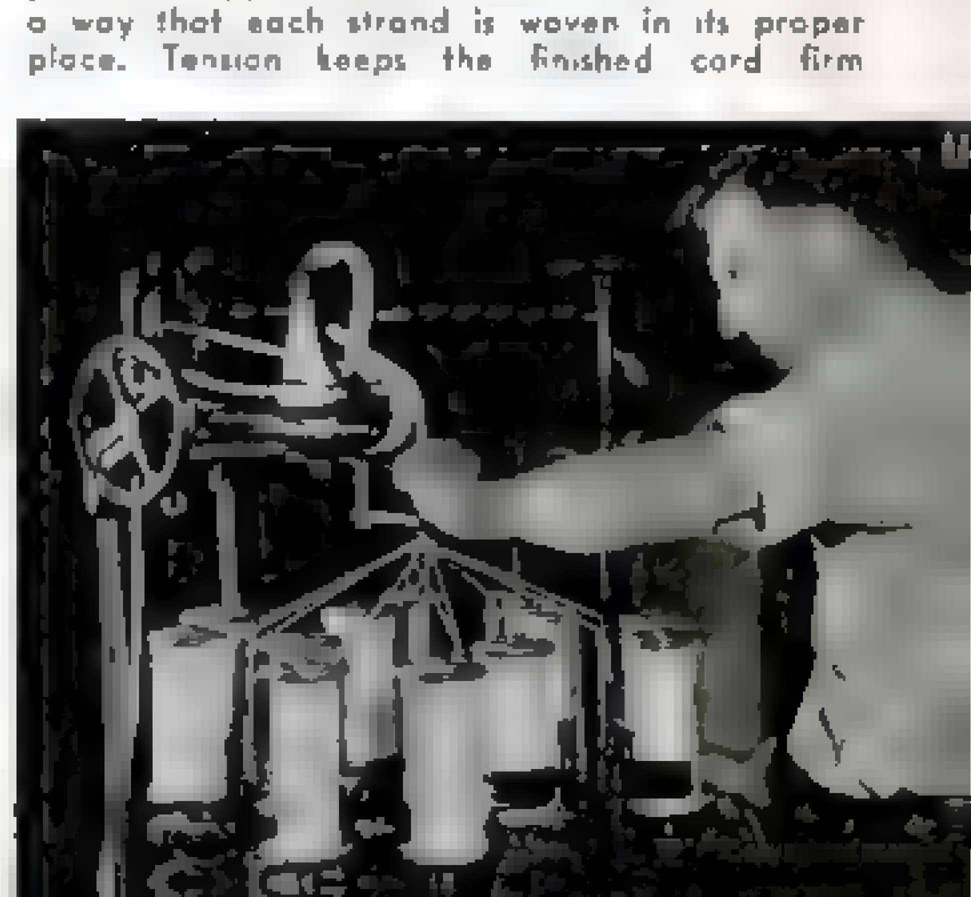
Although smaller in diameter than a pencil, some of the cord being fabricated for military uses has a tensile strength of hundreds of pounds. To make it, machines that once turned out a linen salt-water fish line now fashion the filler from three twisted strands of rayon thread, which then are braided over with rayon cover stock. The finished cord is spooled in 600-foot lengths. [CONTINUED]

How twelve Nylon strands become a glider tow rope. A close-up of the braider shown below

Time exposure of bobbins in motion as they revolve and weave the multiple-end strands of Nylon above. This cord—used for glider towlines—is light and elastic and has a breaking strength of 1 300 pounds

Another view of the braiding machine. When power is applied the bobbins revolve in such a way that each strand is woven in its proper place. Tension keeps the finished cord firm





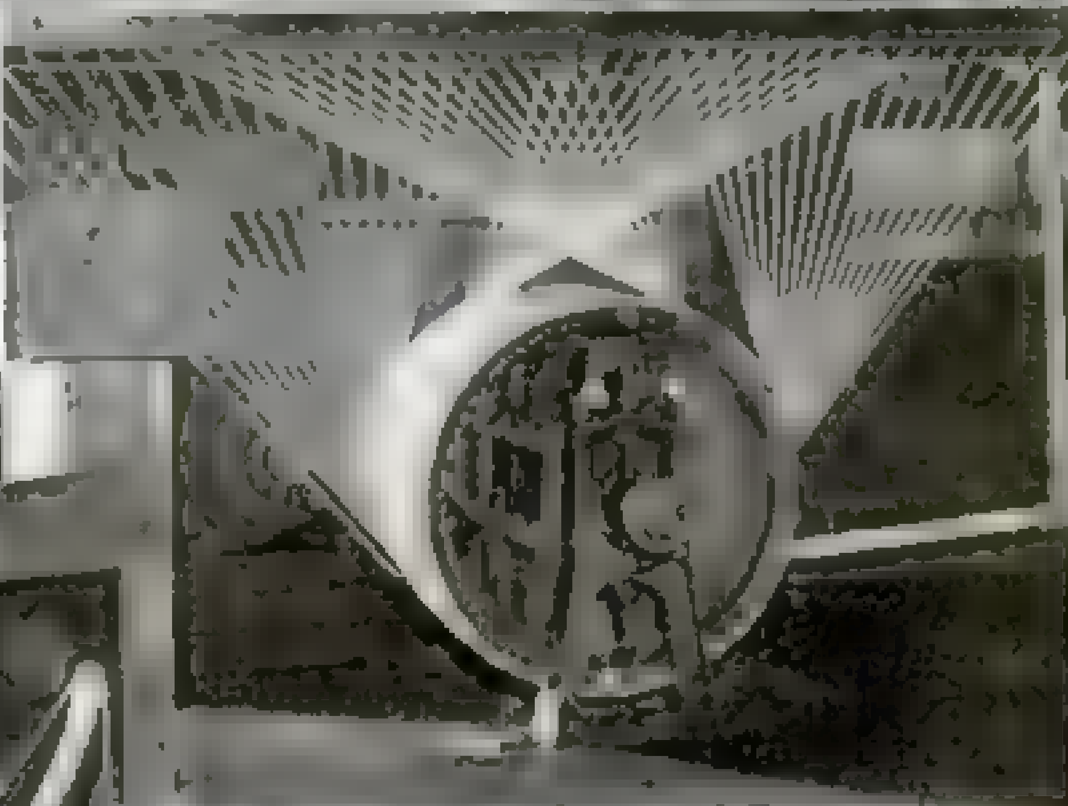
Some time before the war, the Ashaway firm developed a special cord for pickup devices, which enable planes to take aboard air mail without landing. More recently, the Army has tested the Nylon rope as a towline for gliders, and is said to have found it highly efficient, because of its elasticity and high tensile strength. The makers hold that the material has even better elasticity than rubber, because it can be stretched more often and still return to its original size; rubber stretches farther, but wears out much faster. To make the pickup ropes, single strands of Nylon thread are fed from factory bobbins into a large twisting machine that spins them into yarn. This multiple-end yarn is then spooled on other bobbins, which are placed in a "sash-cord" braiding machine. When the braider is started, the bobbins revolve in such a way that twelve strands of Nylon yarn are interwoven into a single rope. By keeping just the proper tension on the bobbins and on the feed, operators obtain a closely woven cable that will not unravel.

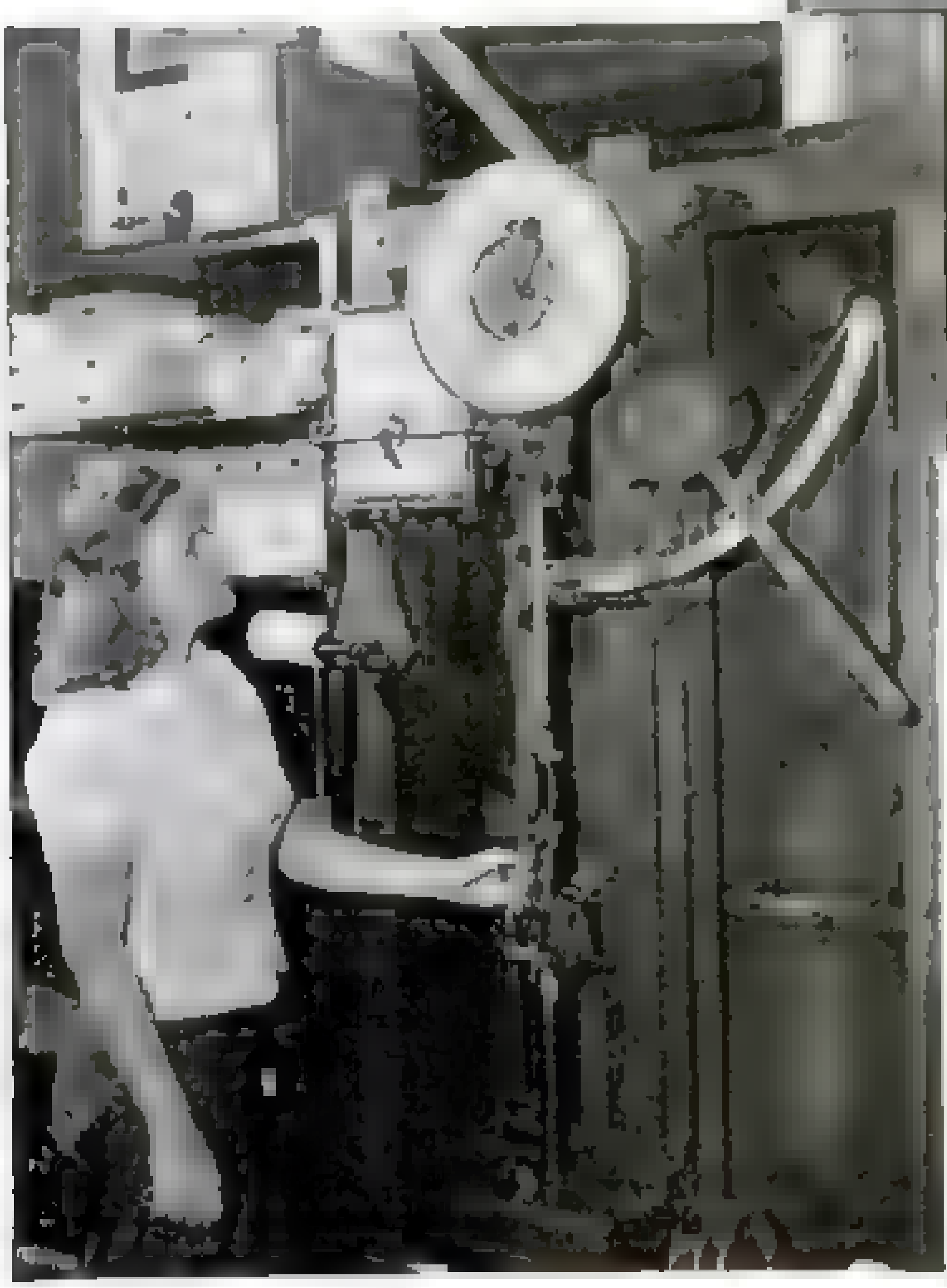
Silk and Nylon sutures, used in surgery, have been made by the Ashaway Line and Twine Manufacturing Company for many years, but now, instead of having many customers for their product, they turn over the greater part of their entire output for the use of the armed forces. Raw silk and Nylon are used for making sutures and priorities are given to plants doing the Government's war work and also the civilian hospital work, as that, of course, is still necessary. Ends of the silk or Nylon are twisted into a thread, which is then braided, treated, spooled, and sterilized.

Nylon thread comes to the line and twine manufacturer on bobbins of single strands. These are put on a large twisting machine that twists the single strands into multiple ones, thus making them stronger. Above, three strands are being twisted into one

Heavy cotton lines similar to those used by masons and carpenters are usually twisted in a long, barnlike structure known as a "line walk." This is one of the oldest processes in the line manufacturing industry. Here strands of light cotton thread are warped by hand the full length of the walk, which usually extends for a distance of more than 700 feet. Each end of the strand is attached to a twister which, when set in motion, twists several strands together to make bigger and stronger cord. When a hard, high tensile strength is needed, another set of strands is twisted with the first, but in the opposite direction in order to lessen the chance of unraveling. Most of the cotton lines are now being used by shipbuilding companies in the gigantic task of turning out naval and cargo vessels.

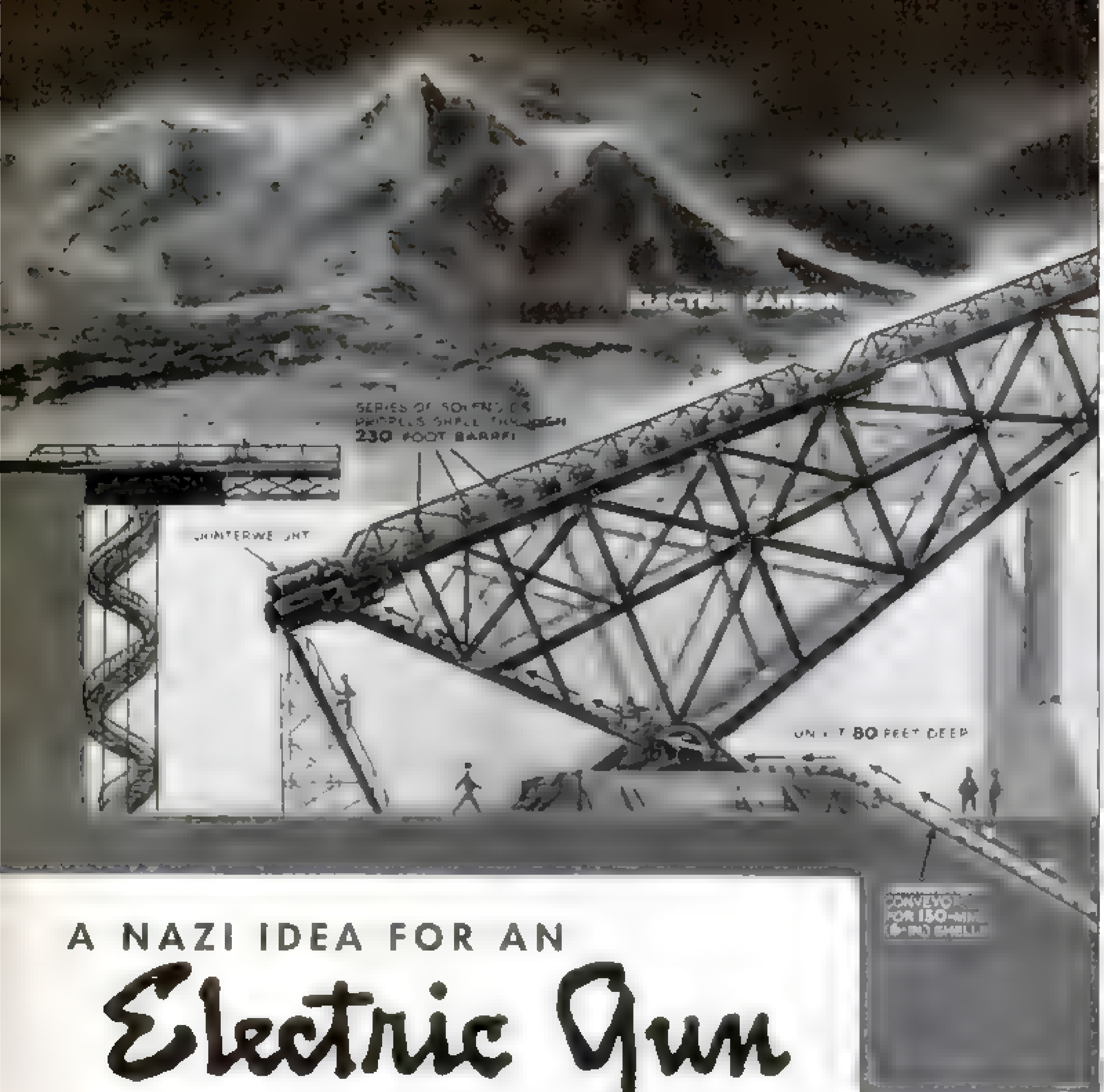
Each piece of line or twine manufactured must meet certain rigid tensile requirements. To make sure that each product meets these requirements, a sample is put in a testing machine. Ends of the cord are clamped between two sets of jaws, which are spread apart, slowly stretching the line to its breaking point. As the cord snaps, the tensile strength is recorded at its highest point on a graph attached at one side of the machine.





At top, a "line walk" extending 725 feet down one side of a twine plant. Lines are laid by hand and then twisted by an electric twisting machine shown in the close-up, which is placed at one end. Each cord is attached to a separate twister that spins when power is applied. Heavy cotton lines twisted here are used on board ships. Formerly they were manufactured for masons and carpenters

To meet rigid strength specifications, samples of each cord are tested for tensile strength on the machine at left. Samples are stretched until they break, and this point is recorded on a graph



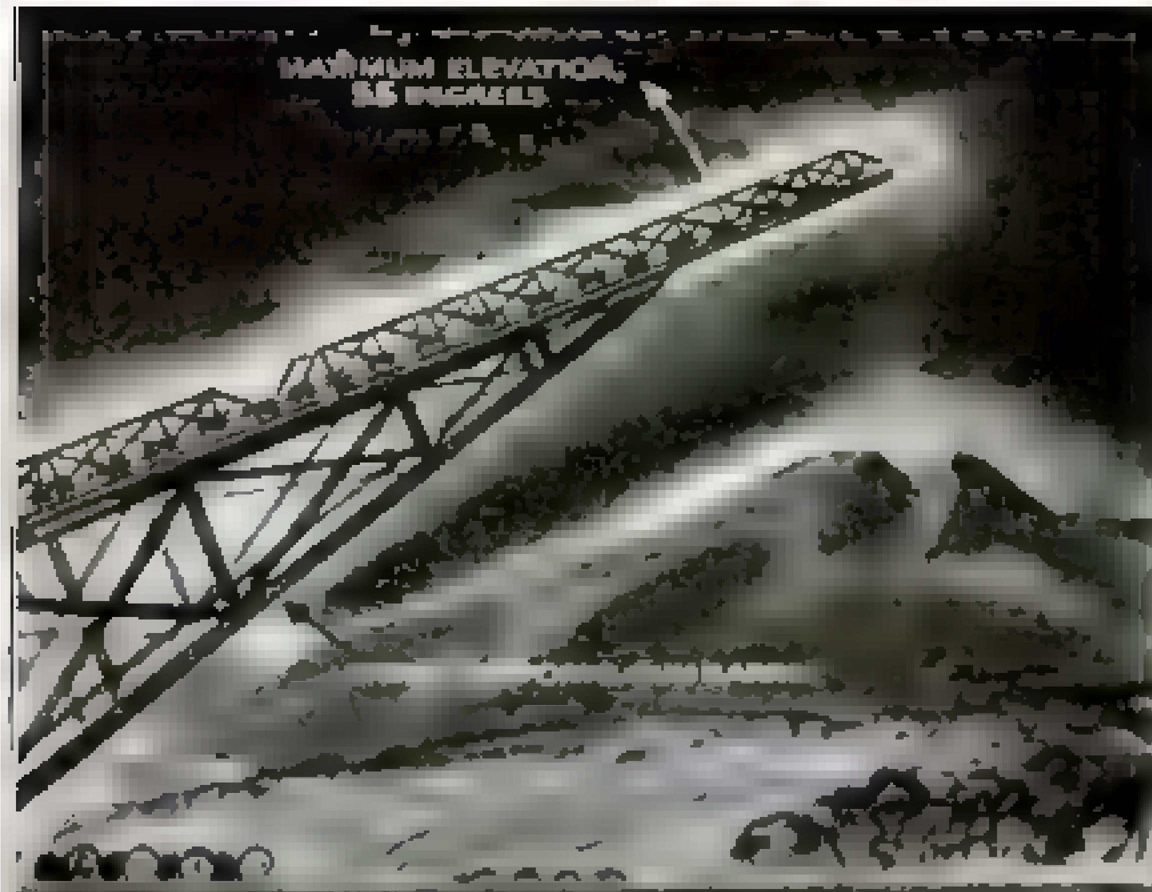
A NAZI IDEA FOR AN

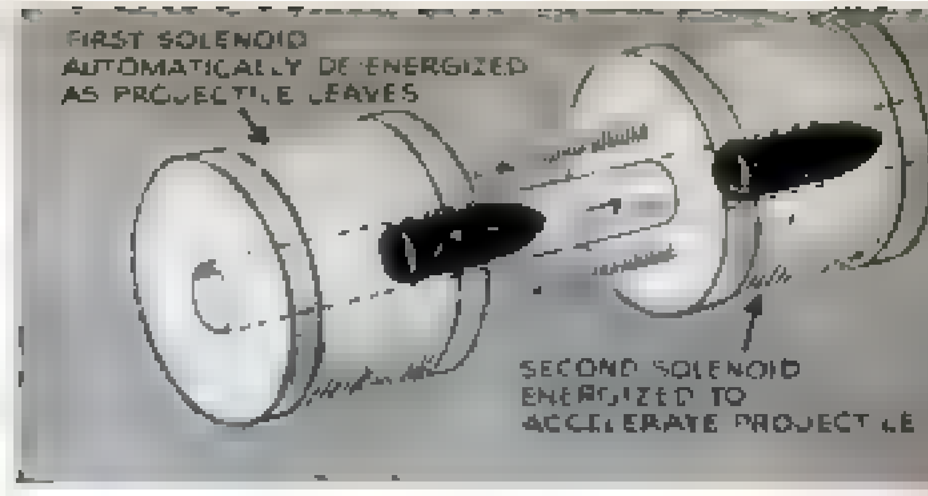
Electric Gun

IMAGINE a rapid-firing electric cannon, capable of raining 750 six-inch shells a minute upon a target 90 miles away! Outranging the long-distance guns that bombarded Paris in the First World War, such a weapon is proposed in a French edition of the German periodical "Signal." Is artillery of this kind to be a possibility of the future?

As depicted, the scheme calls for a huge gun with a thin 230-foot barrel. Solenoids, or coreless electromagnets, encircle the tube at regular intervals from its breech to its muzzle. When a firing switch is closed, the first solenoid magnetically attracts the missile and starts it on its way. As the shell passes through it, this solenoid goes dead and the next one takes up the pull, until successive impulses give the projectile a muzzle velocity of more than a mile a second. A high-speed automatic conveyor feeds ammunition. When not firing, the gun lowers for concealment beneath camouflaged covers

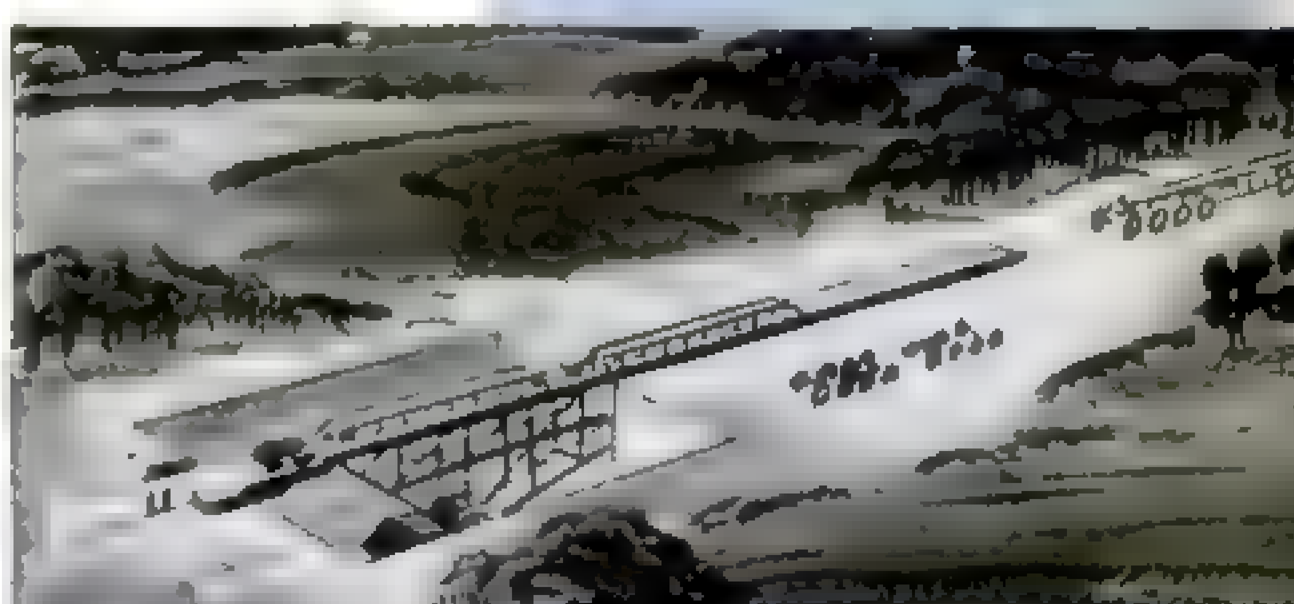
Formidable as it sounds, the idea invites critical analysis. First, just what is this gun intended to do? At its extreme range, precision firing upon small targets such as ships and troop concentrations would be out of the question. A more likely task would be to shell a large city at random. London could be bombarded from clear across the Channel. But here the gun takes on a job for which bombing planes are pre-eminently suited. Presumably the cannon would be of





MAGNETISM REPLACES POWDER IN THIS NAZI DREAM WEAPON

Looking more like a drawbridge than a piece of artillery, the odd structure at the left is our artist's conception of the electromagnetic cannon proposed in a German publication, as it rises from concealment to hurl 750 six-inch shells a minute at a target 90 miles away. Subterranean, bombproof galleries house the control room and ammunition magazine, from which an endless conveyor feeds shells automatically to the gun. Spaced along the slender tube as seen above, coreless electromagnets are energized in rapid succession to whip the projectiles through the barrel, which they leave with a muzzle velocity of more than a mile a second. Absence of explosive blast makes a thick barrel unnecessary, and recoil takes effect only on the magnets and their supporting framework. Shells of special design could be rotated electrically to steady their flight, the effect obtained by rifling in an ordinary cannon. A vulnerable target for hostile bombers because of its fragile construction, the gun may be shifted from one emplacement to another in three sections, on trailers drawn by powerful towing trucks. The sketch above shows the 230-foot tube being reassembled at an emplacement. For comparison, a conventional gun of the same caliber has a 20-foot barrel and a maximum range of about 14 miles



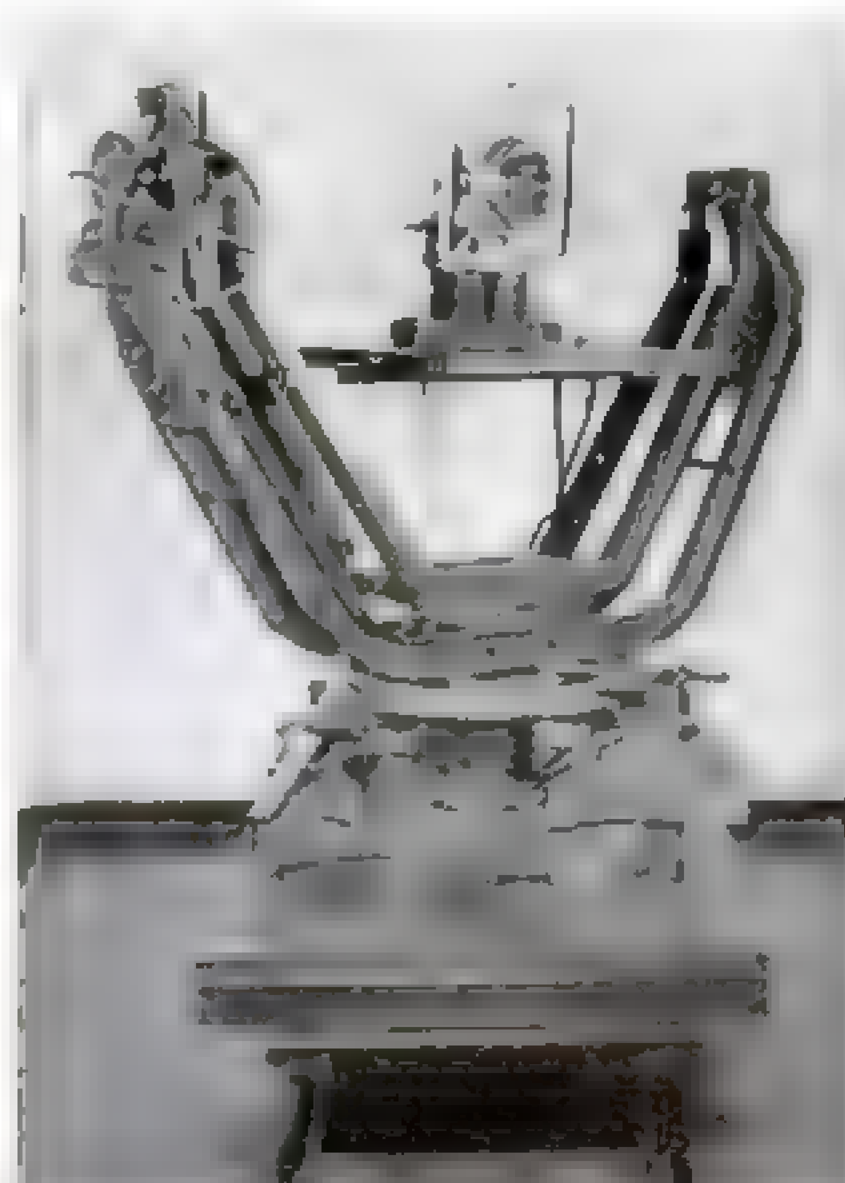
most interest to a belligerent shorn of air power. The damage inflicted by one of its high-explosive shells would be exceeded by an air bomb of only 250 pounds—a modest size, indeed, compared to a modern 4,000-pound "block buster."

An embarrassing problem remains—where to get the 1,000,000 kilowatts of power needed to operate the gun. No generating station in all of Germany has this capacity. Interconnected sources of current might be used, but only at the cost of a "blackout" of vital Axis industries using electric power. Perhaps the grandiose idea simply needs radical scaling down. Small electric guns have been devised by inventors in many lands, and some model may yet compete with those that use gunpowder.

Helping

Streaking out its bright shaft as it will later on the wing of some fighting plane attempting a night landing, this aircraft lamp makes an eerie picture breaking through the blackness of the testing room at the Westinghouse plant in New Jersey. Three technicians test the lamp. The one shown here in the reflected glow mounts it on a carriage so that its beam will strike a distant photoelectric cell

Below the operator adjusts the beam to spear it down the long passageway where a second technician in the distance takes data from a recording meter attached to the photoelectric cell. At the right is a view of the trunnion carriage on which the tested lamp is mounted



Planes to See at Night

EXPERT TEAM PUTS AIRCRAFT LAMPS THROUGH RIGID TESTS TO ASSURE SAFETY OF WAR FLYERS ON UNLIGHTED FIELDS

ALONG an indoor railway track, 100 feet from end to end, trundles one of the strangest of testing instruments in the Westinghouse lamp plant in New Jersey.

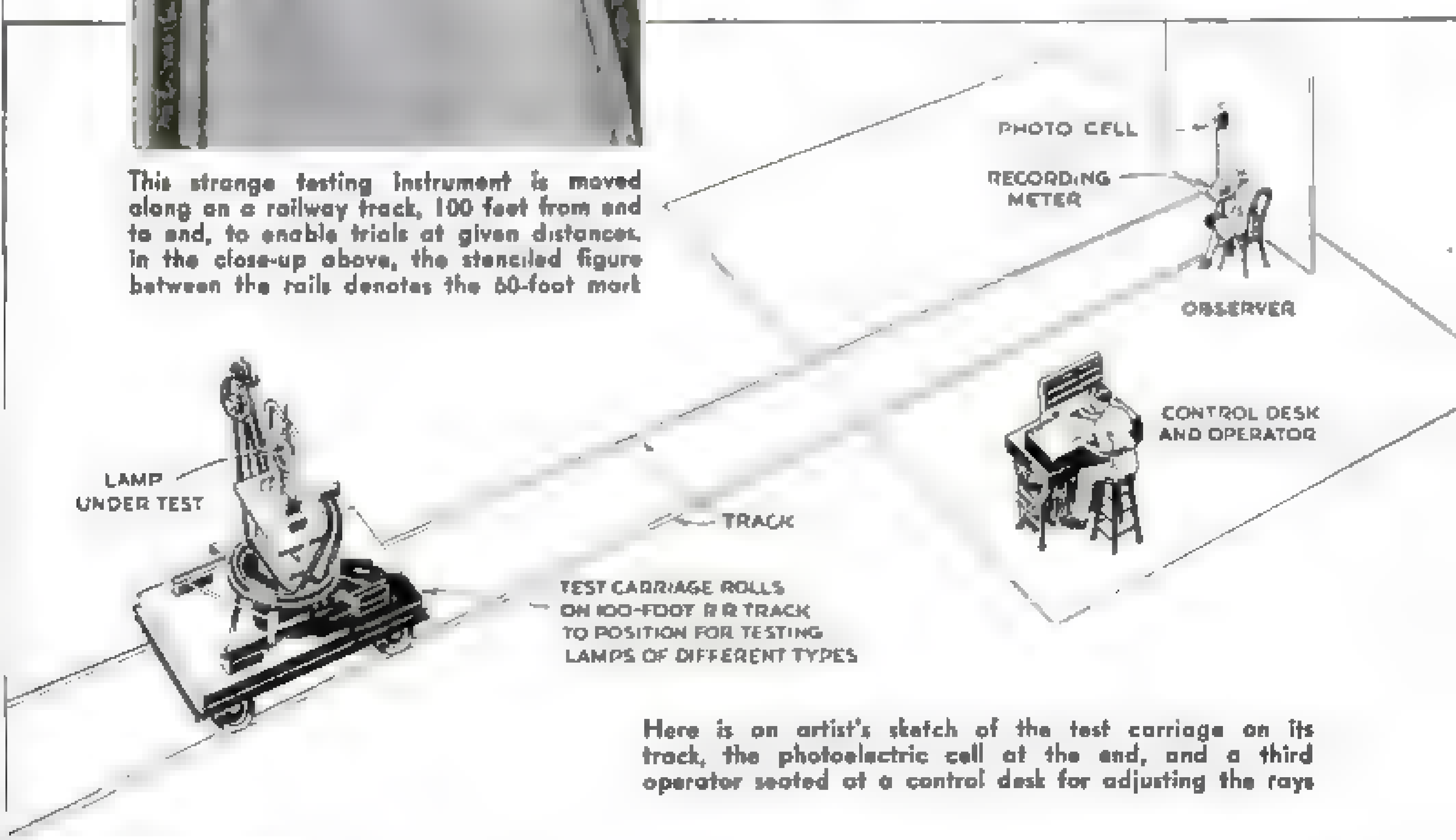
Serving as a gigantic "optical bench," it carries an airplane lamp for a trial of the beam's brightness and pattern. Precision measurements like this assure the safety of a war pilot who will use a pair of the same lamps, installed on his plane, for the few critical seconds of a night take-off or landing on an unlighted runway somewhere in the battle zone.

This strange testing instrument is moved along on a railway track, 100 feet from end to end, to enable trials at given distances. In the close-up above, the stenciled figure between the rails denotes the 60-foot mark

Here is a new type to be tested, resembling a "sealed-beam" auto light in its waterproof construction. Its two halves of heat-resistant glass, one of them aluminized as a reflector, have been fused together. Gas-filled with nitrogen and argon, the largest model emits more than 750,000 candlepower, although consuming no more power—a mere 600 watts—than a household toaster. Other details that might interest the enemy will not be mentioned here, except that its makers believe it to be the most efficient of its type.

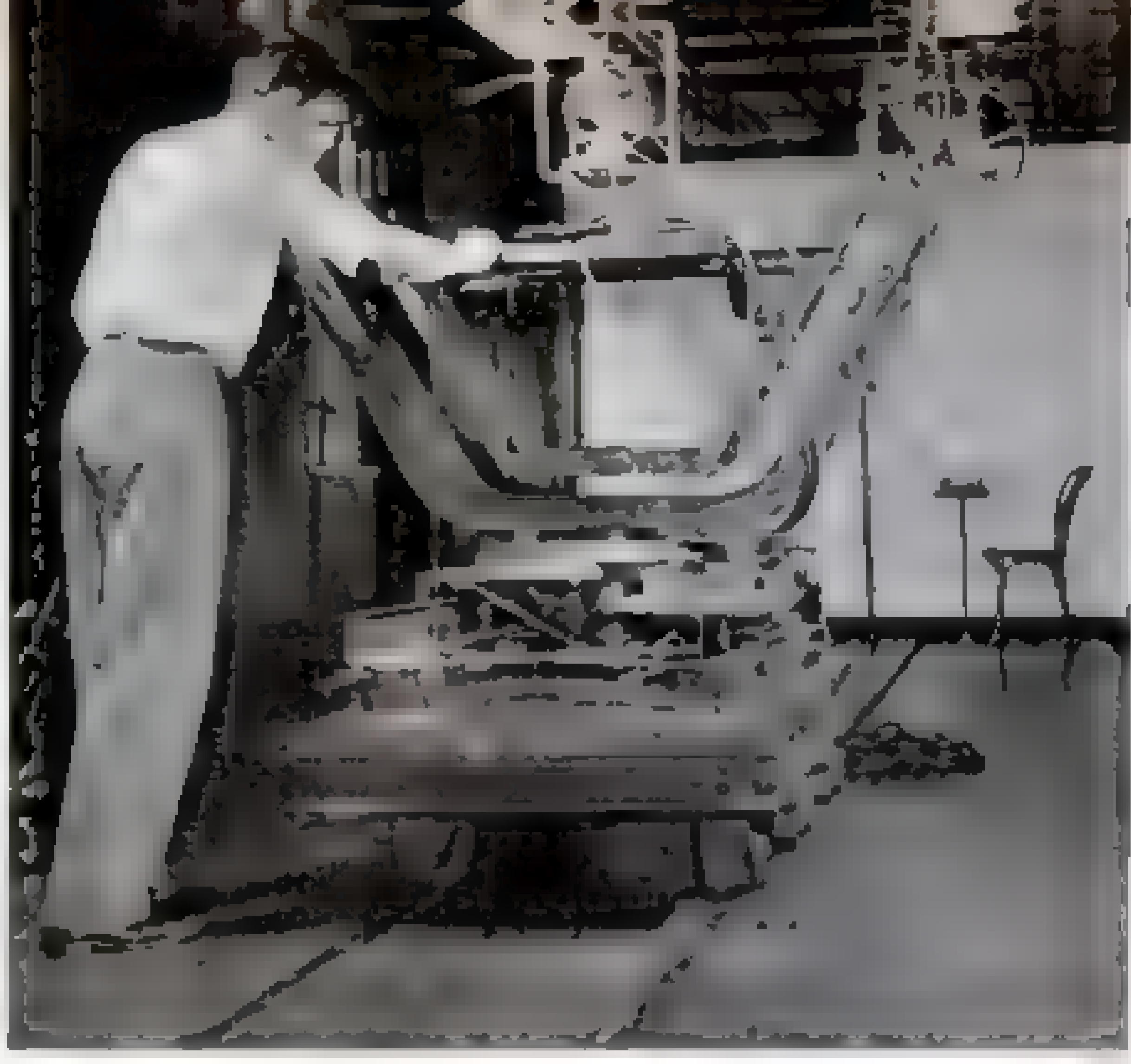
Three laboratory technicians, as a rule, test the beam. One mounts the lamp in the massive trunnion of the test carriage, which is moved along the rails of the indoor track, say, to a 60-foot mark stenciled between them on the floor. Other distances may be used, according to the size and power of the lamp.

Now the second operator comes into the picture. Seated at a control desk suggesting



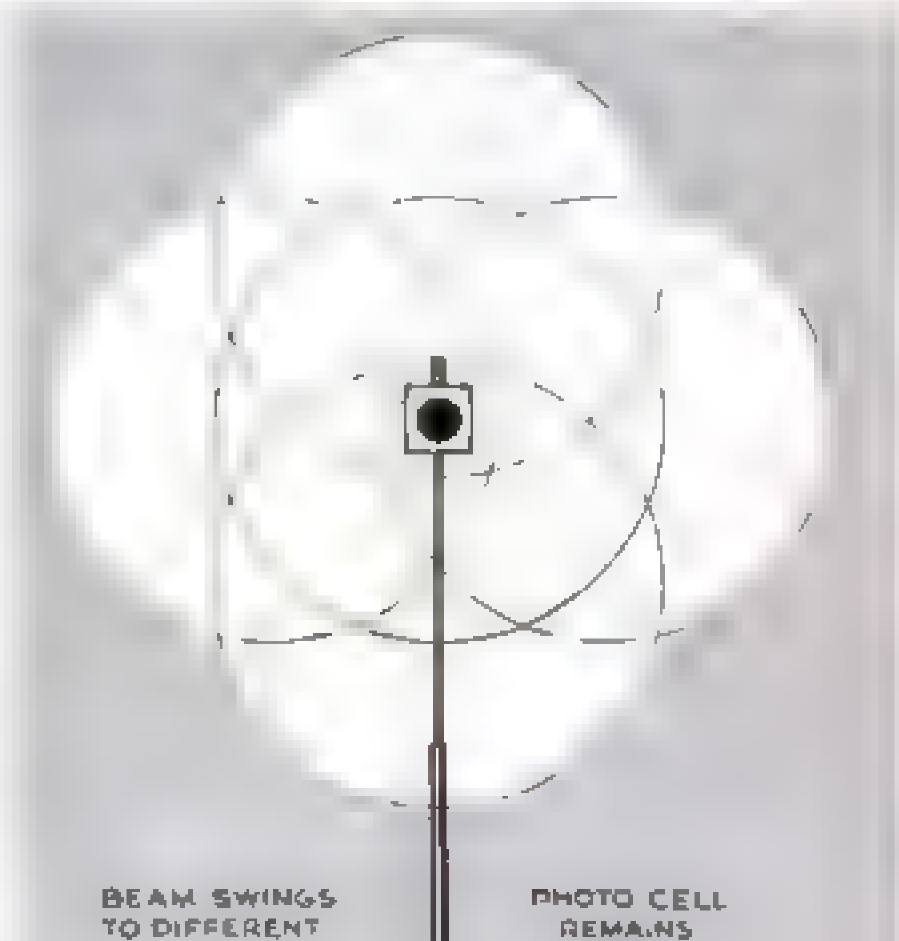
Here is an artist's sketch of the test carriage on its track, the photoelectric cell at the end, and a third operator seated at a control desk for adjusting the rays

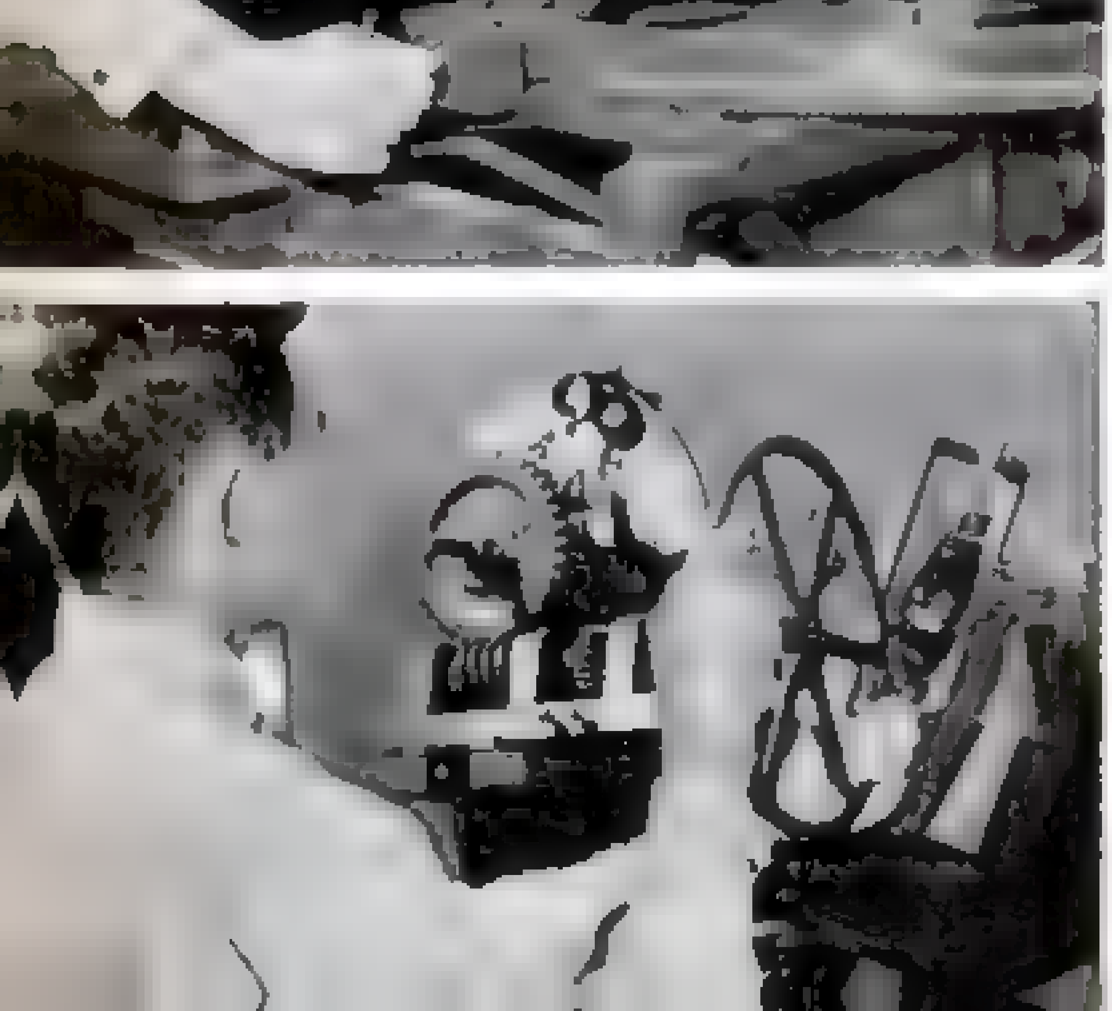
Like an antiaircraft gunner drawing a bead, the operator can swing the airplane lamp in this frame to strike the photo cell with its beam



Once mounted, the lamp is pushed on its trunnion carriage to the proper distance from the photoelectric cell. This point varies, according to the size and power of the lamp. Through teamwork, operators obtain quick and accurate results, even in a dark room

HOW BRIGHTNESS AT VARIOUS POINTS OF BEAM IS MEASURED





Instead of moving the photo cell to measure the brightness of the beam, the lamp is swung both horizontally and vertically on the trunnion of the test carriage, as indicated in the drawing above. The lower photograph at left shows the hand wheel and dial for vertical adjustment and that above it, the horizontal mechanism

He is a busy man. Some of the controls on the desk are operated by hand and others by foot. In the photograph above, one of the multiple rheostats is being adjusted by pressure on a pedal. In these manipulations actual conditions are reproduced

Seated at a control desk that looks something like an organ console, the operator above adjusts the supply of direct current to the lamp by setting rheostats and reading meters until it is being fed at just the right voltage and amperage for the unit that is undergoing tests

On a meter connected to the photo cell, a needle indicates brightness at the center of the beam. When the lamp moves up or down, as on the facing page, the intensity at other points is recorded

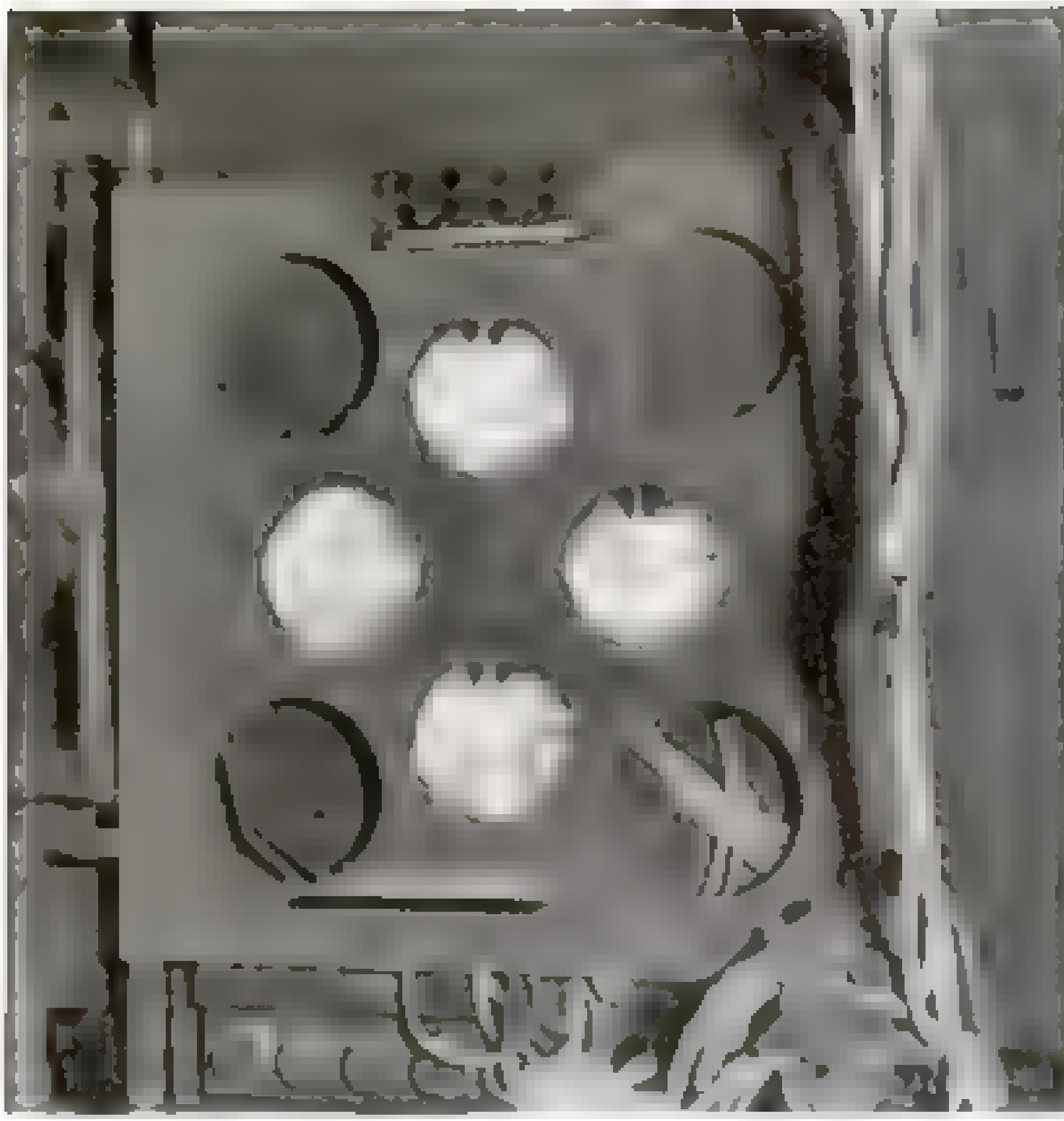
an organ console, he adjusts a supply of direct current to the lamp, until meters show him that it is being fed at just the voltage and amperage required for the test. A busy man, he operates some of his controls by hand, others by foot. At this point the beam spears a straight line right down the middle of the track, and falls squarely upon a photoelectric cell stationed at its far end.

On a meter connected to the photoelectric cell, a needle swings across a graduated dial. Here an observer notes or calls out the reading of the needle, which indicates the brightness of the lamp at the very center of the beam.

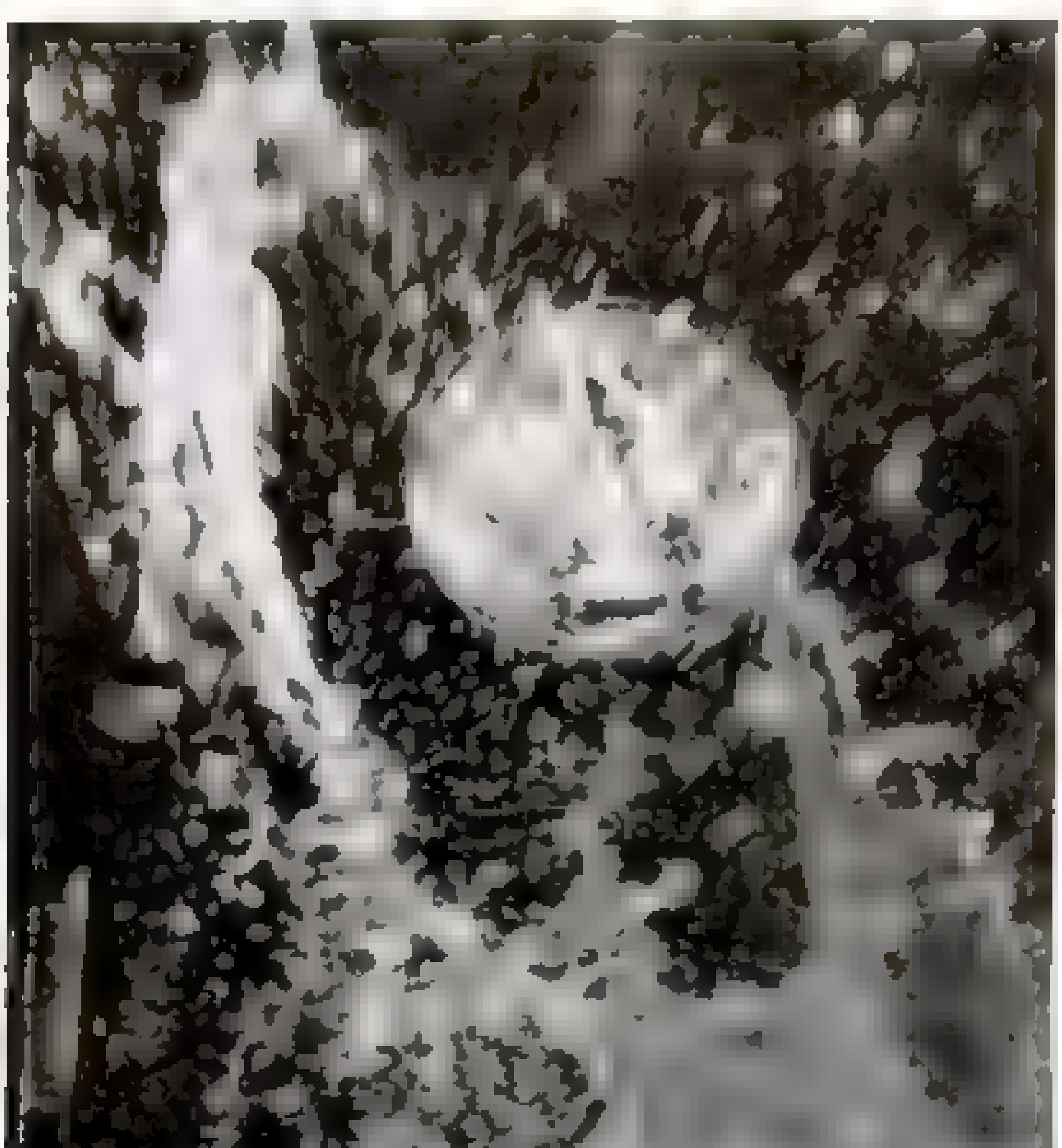
Now to explore the intensity of the beam at other points than its center, so that charts may be made of the areas or patterns receiving equal amounts of light. To an engineer, these will show the pattern of useful light from an airplane lamp, just as it would show that from an automobile headlight illuminating a dark road.

To do this, the photo cell might be moved across the beam, vertically, horizontally, and diagonally, taking measurements at regular intervals. Instead, Westinghouse engineers find it more convenient to keep the photo cell stationary, and swing the beam itself.

Like an antiaircraft gunner drawing a bead upon an enemy plane, the operator of the test carriage spins a hand wheel that elevates or depresses the beam by the num-



Airplane lamps also undergo life tests. Four are shown here on a standard test panel. They are turned on five minutes, off five, until they fail. Average life is about 24 hours



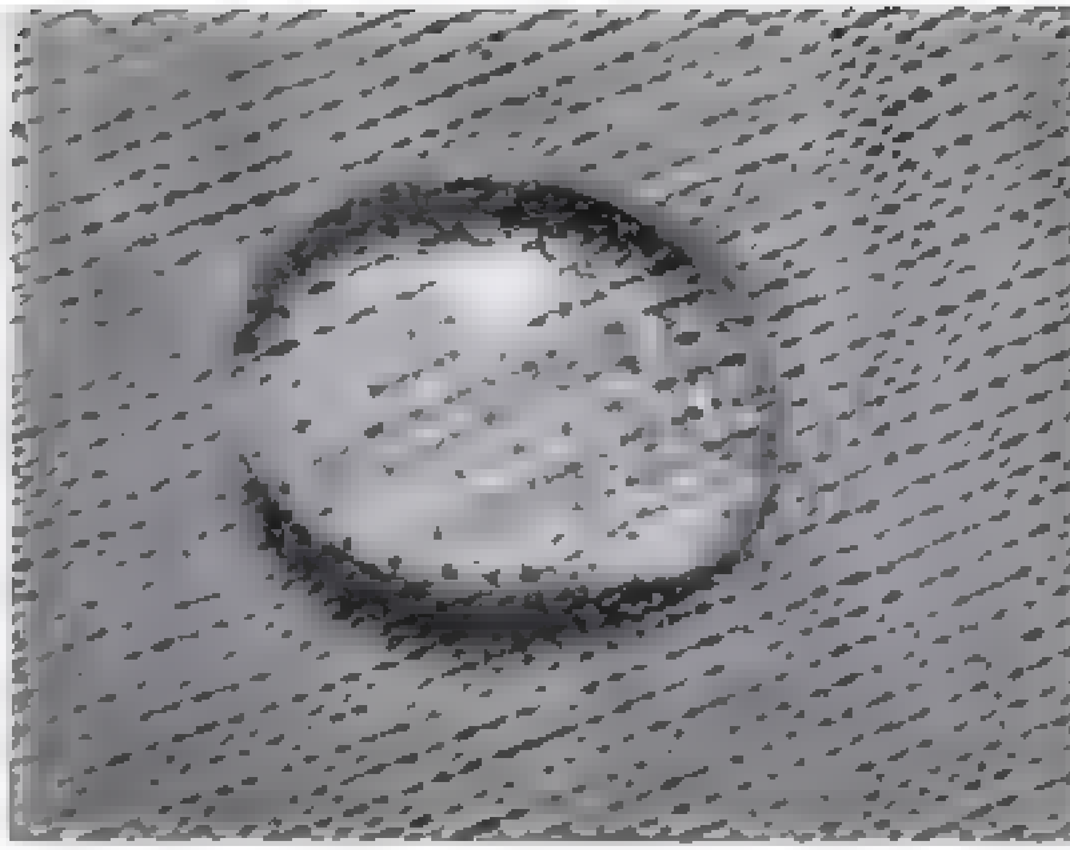
And then comes the splash test where water is dashed on a lighted lamp to make sure that the greatly heated glass will not crack under the strain. The glass used has consistently proved so tough that this test has since been discontinued

ber of degrees indicated on a dial. Likewise, releasing a lock at the base of the trunnion permits him to revolve the beam horizontally past a second dial. By combining the two movements, any diagonal placement of the beam may be attained, until all the desired data have been collected. Through the experienced teamwork of the two operators and an observer, quick and accurate results are obtained, even in the darkened chamber required by the conditions under which the test is made.

Mounted on a panel in another building, lighted by the glare of hundreds of bulbs undergoing endurance trials, the airplane lights get their "life test." A time clock automatically turns them on for five minutes and off for another five minutes, until they eventually fail. For maximum brilliance, the airplane lights, like photoflood bulbs used by camera men, are purposely overloaded with voltage. Hence their comparatively short life, which is something like 24 hours. But the few moments in which they are used, when a plane alights or takes to the air, make this a minor consideration. They can easily be replaced before there is any danger that they have reached the end of their useful life.

A "splash test," originally given the airplane lights, has now been discontinued. At first it was believed that the searing-hot glass might break when subjected to the terrific strain of a cold-water dousing from puddles in the runway, or from a seaplane landing. But when the lamps were lit to full brilliance, and dunked with a shower of water, the glass consistently proved tough enough to take it. However, for the benefit of this magazine's readers the splash test was re-performed, without the slightest damage to lamp, camera, or POPULAR SCIENCE's reporter or photographer. The light went right on shining brilliantly—as others like it will do when Uncle Sam's fighting planes set off on night missions and return with reports of thrilling new victories.

Chemists Promise Water-Repellent Cotton Stocking To Look Like Silk

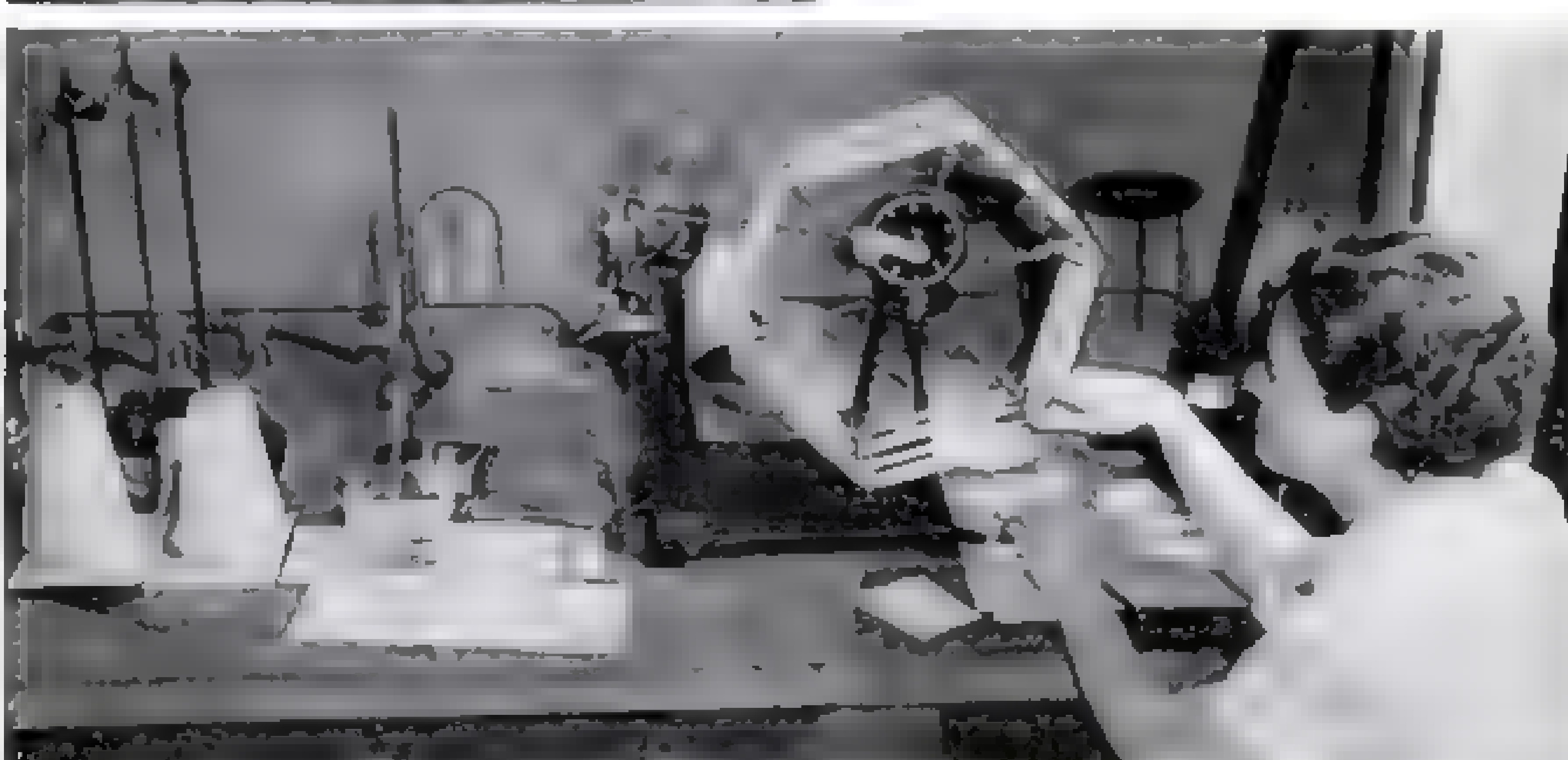


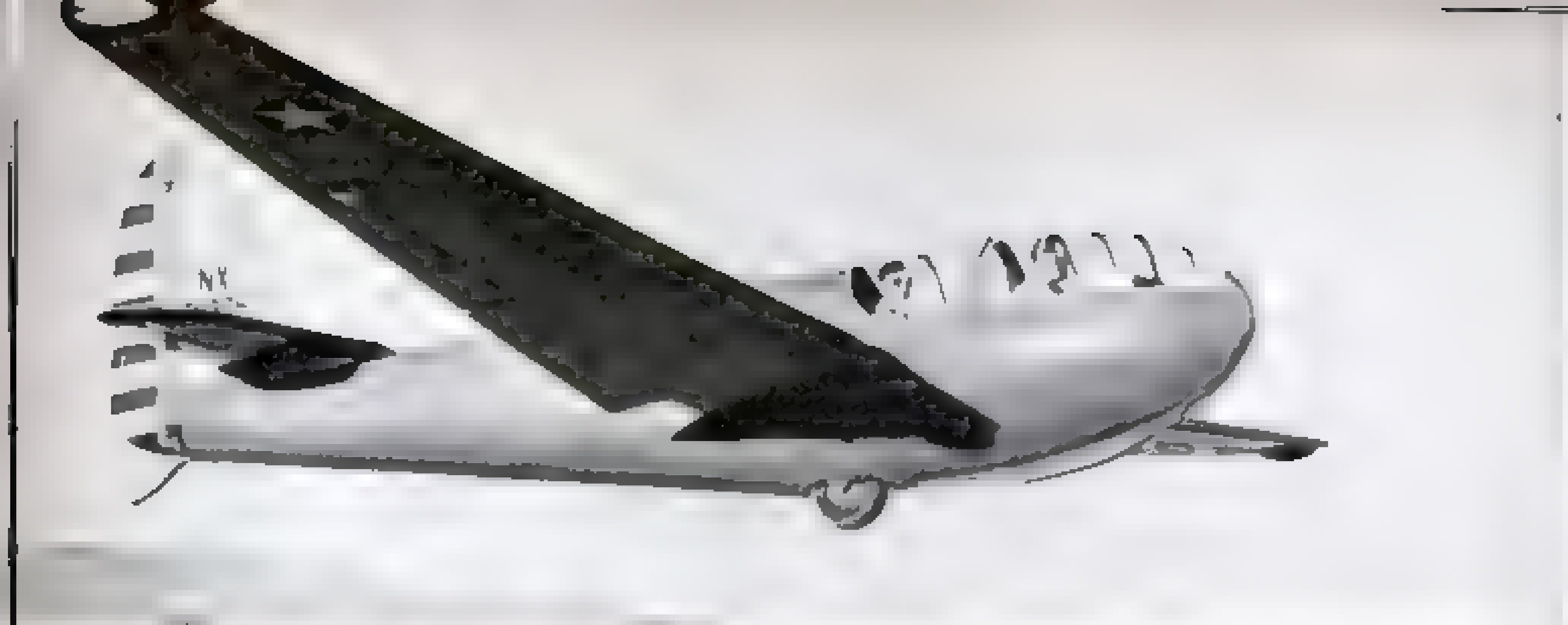
Here's good news for the ladies! A drop of water proves the water-repellent qualities of the new stocking material being developed by Government chemists

ATTRACTIVE, water-repellent cotton stockings for women are promised as the result of research now being made at the U. S. Bureau of Home Economics in Beltsville, Md. Government chemists have taken a natural, unmercerized yarn, treated it for elasticity, and "splashproofed" it so that rain or mud stains can be wiped off. Although still in the development stage, the hose is expected to have the qualities of silk.

In the test at left, a drop of water is put on a piece of the fabric stretched across a beaker. After standing for five minutes, the water is removed and the fabric is examined to see how much has been absorbed. Mud and rain stains can be wiped off the new hosiery

Below, a Beltsville textile chemist reels up natural cotton yarn that has passed through a glass dish containing a solution designed to give it elasticity. As a result of these tests, American women may soon be able to buy cotton stockings that look and wear like silk





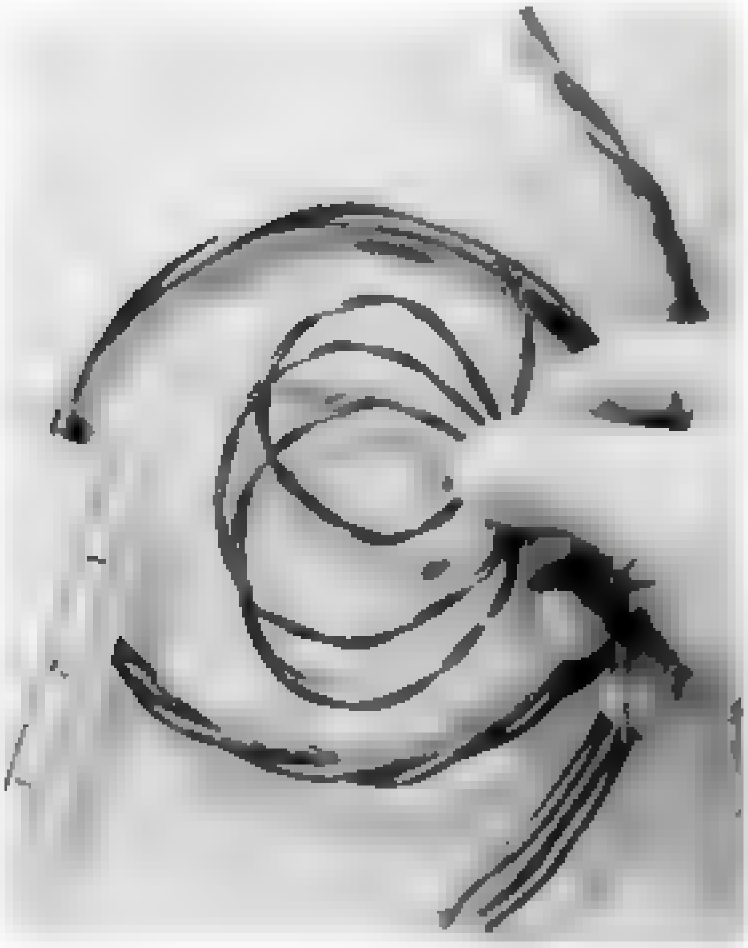
PLYWOOD in the AIR

THIS TWO-PLACE GLIDER TRAINER, built for the Army by Bowlus, is made entirely of plywood and other nonstrategic materials, molded with phenol and area-type bonding. It is completely nonmagnetic, and therefore cannot be detected by listening devices. Designed speed is 112 m.p.h. This trainer is called the forerunner of giant cargo gliders.

MILITARY MANEUVERS and acrobatics are possible with the Ryan PT-24 primary trainer constructed chiefly of plastic-bonded plywood. The view at right above shows the plywood parts, while immediately below this is a completed plane with power plant installed

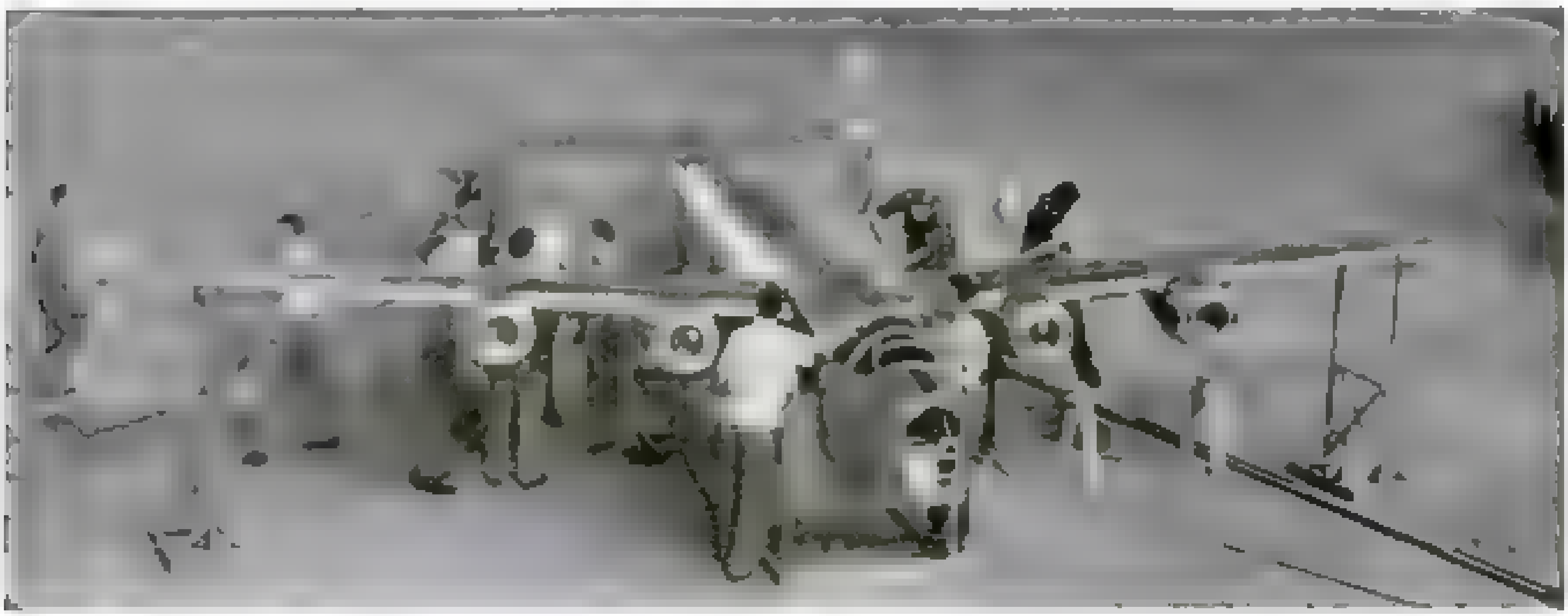
BOMBING CREWS TRAIN in the Fairchild AT-13 two-engined bomber below, also built of plywood except for certain equipment supports. Units are "cooked" together to eliminate rivet heads and laps

CARRIED BY PARATROOPS, the Reising .45 caliber submachine gun at the right is a light, powerful weapon in the hands of our airborne Marines for whom it was developed. The gun with the conventional stock was described by Popular Science Monthly over a year ago (P.S.M., Apr. '41, p. 73). This new adaptation has a pistol grip that makes for ease in firing, and a steel-frame stock, which can be folded against the barrel when the gun is being carried. Part of the stock can be seen on the gun held by the Marine in the photo.



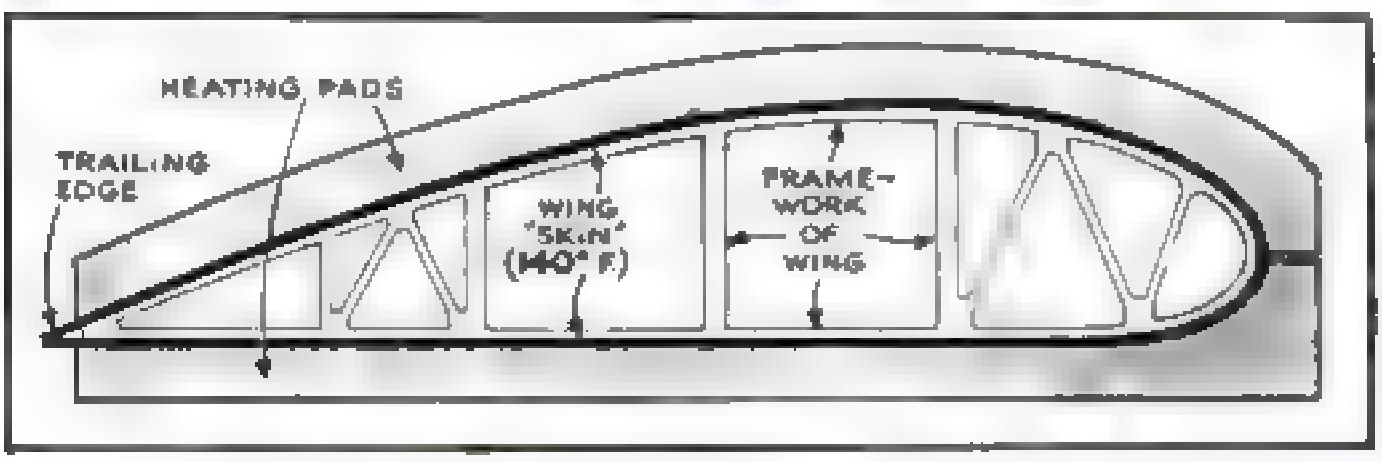
"ASSAULT WIRE" OF LATEX is being manufactured for thousands of miles of Army field telephone lines. This new wire, developed during the last 15 years by the Signal Corps and United States Rubber Company, weighs less than 29 pounds per mile, as compared with an older type that weighed 160 pounds. The wire is carried on reels on the backs of soldiers, and unreeled as they advance in combat.

BANTAM B-24 BOMBERS, one-third actual size and complete in every detail except for engines, are built in a unique school run by the Douglas Aircraft Company at Tulsa, Okla., to teach workers to fabricate them and mechanics to repair them. One bomber rolls off the assembly line every 10 weeks. At the completion of one course, the Army smashes it, and then student mechanics put it together again.



Heat Irons Wrinkles from Plane Wings

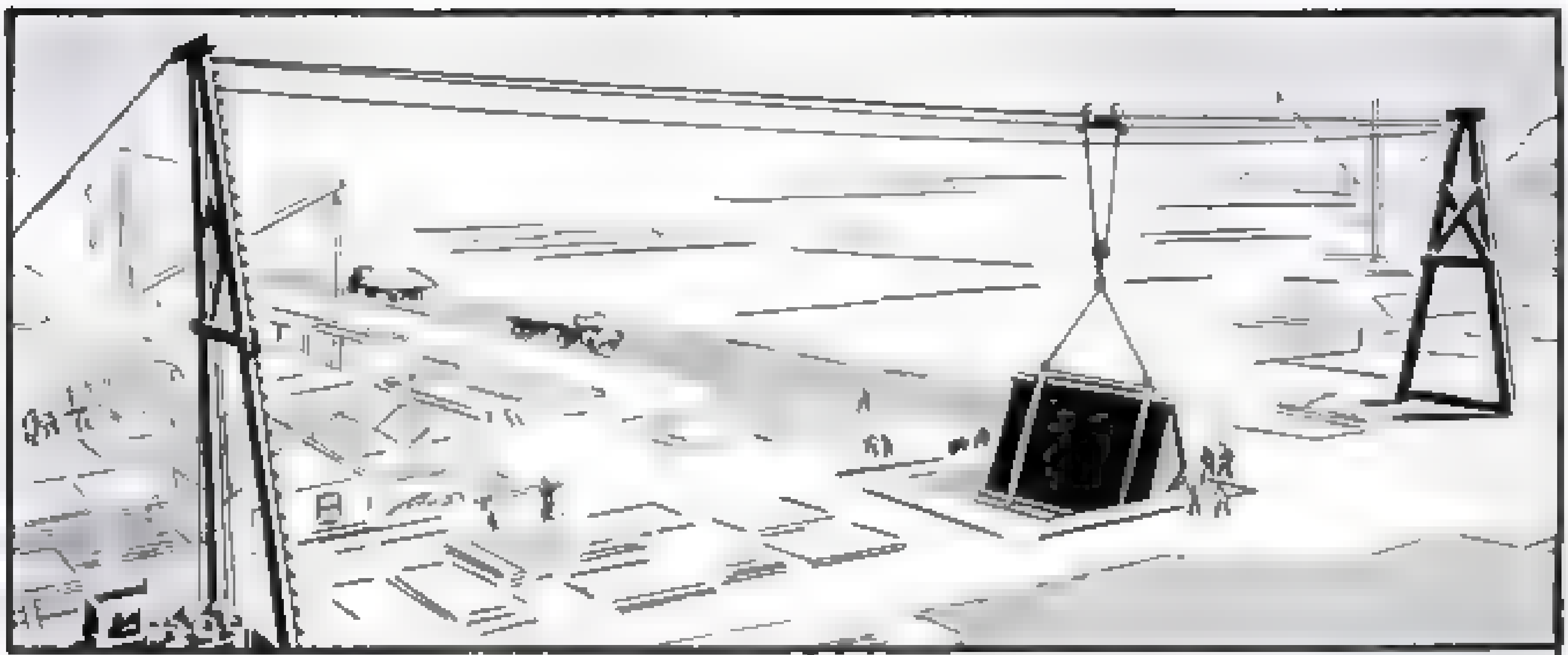
HEAT therapy—hospital style with heating pads—has moved into the Glenn L. Martin Company's airplane plant to eliminate one of the major difficulties of applying aluminum skins to wings. This difficulty, a slight wrinkling of the sheet metal when rivets are set, interferes with the air flow around the wing during flight, cutting the efficiency of the plane. In the heat-therapy process, sheets of aluminum are first riveted together on a wood frame that has the shape of the wing. The skin, now unavoidably buckled, is next placed on the wing structure. Electrically regulated heating pads that fit snugly the desired contour are then laid over the skin. This slightly expands the skin, which is quickly stitch-riveted at the ribs and edges. When the skin cools it shrinks taut.

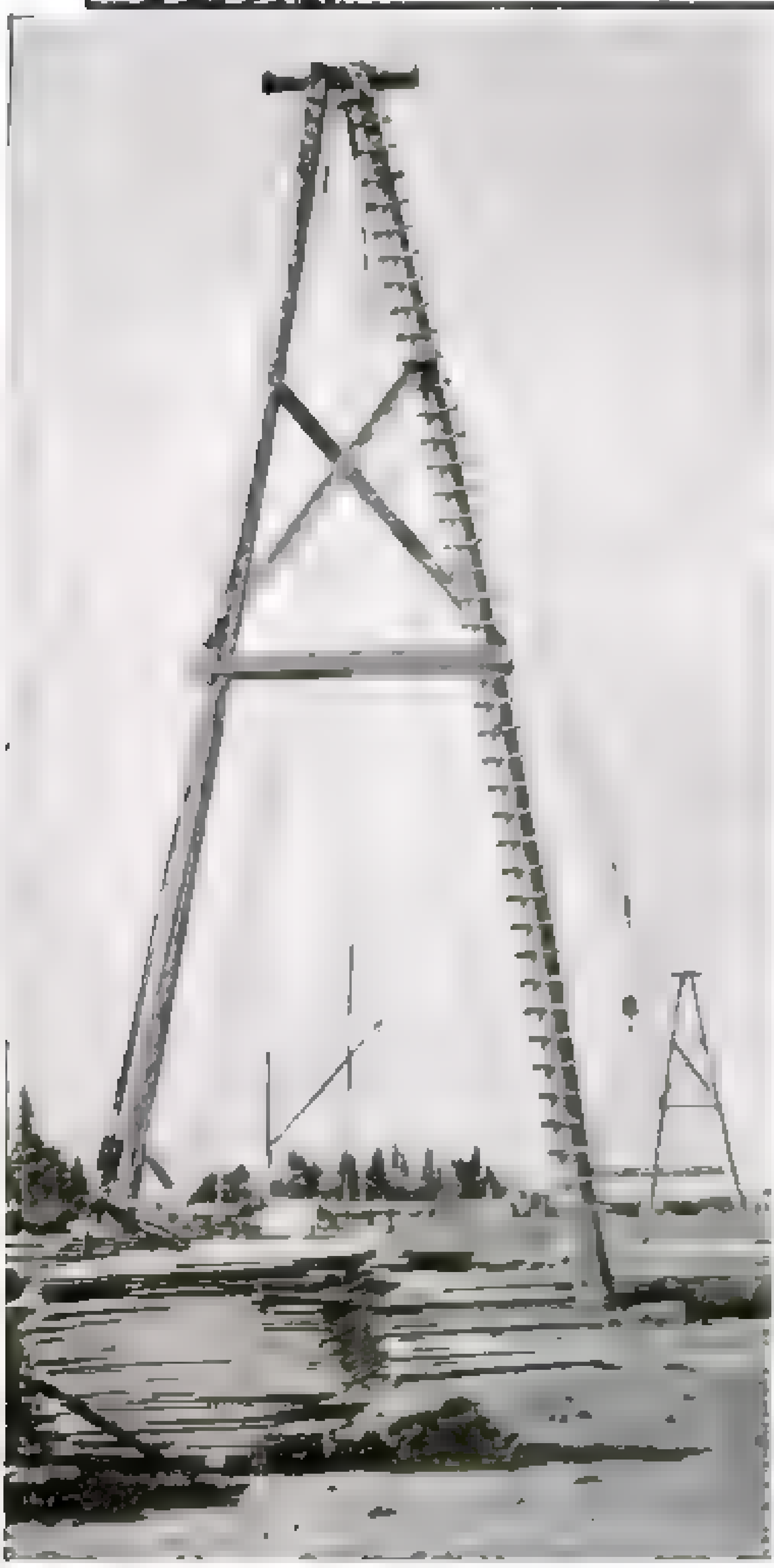


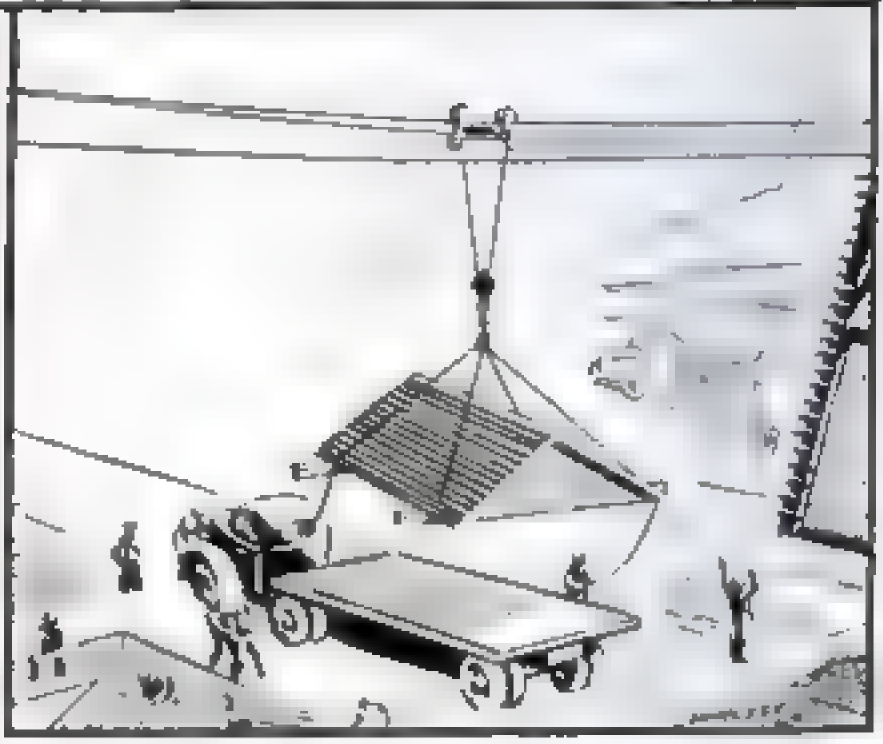
Rheostat-controlled electric heat pads, as shown in photo above and drawing at left, warm the sheet-metal skin on wing frame. This expands the skin for riveting. On cooling, it shrinks

Bottle Hoods Go to War Protecting Plane Parts

CELLULOSE hoods, whose principal peacetime service has been in sealing the stoppers of bottles, are now doing wartime duty protecting open ends of airplane fuel and hydraulic lines, engine ports, and other fittings during assembly and shipping. The hoods, available in many sizes, are simply placed over the openings by hand. Shrinking to a tight fit takes place in a few minutes, giving protection against dust and rust, or against sabotage efforts by enemy agents.







Twin-Towered Hoist Helps Speed Housing Near Big Shipyard

BORROWING a logging-camp transport idea, the Haddock Construction Company of Pasadena, Calif., employs a "highline" in prefabricating 80 ceilings and roofs a day for 3,242 houses overlooking the Kaiser shipyards in Washington.

This "tool" consists of two 50-foot towers 400 feet apart and connected by motor-driven steel-cable pulleys. A ceiling-and-roof section is assembled upside down in a jig below ground level, the "highline" lifts and inverts it on wooden rollers for wire installation and sheathing, and then hoists the completed unit to a truck for delivery to the building site.

Twin-legged towers, five stories high and two city blocks apart, support cables which hoist ceiling-and-roof assemblies during fabrication

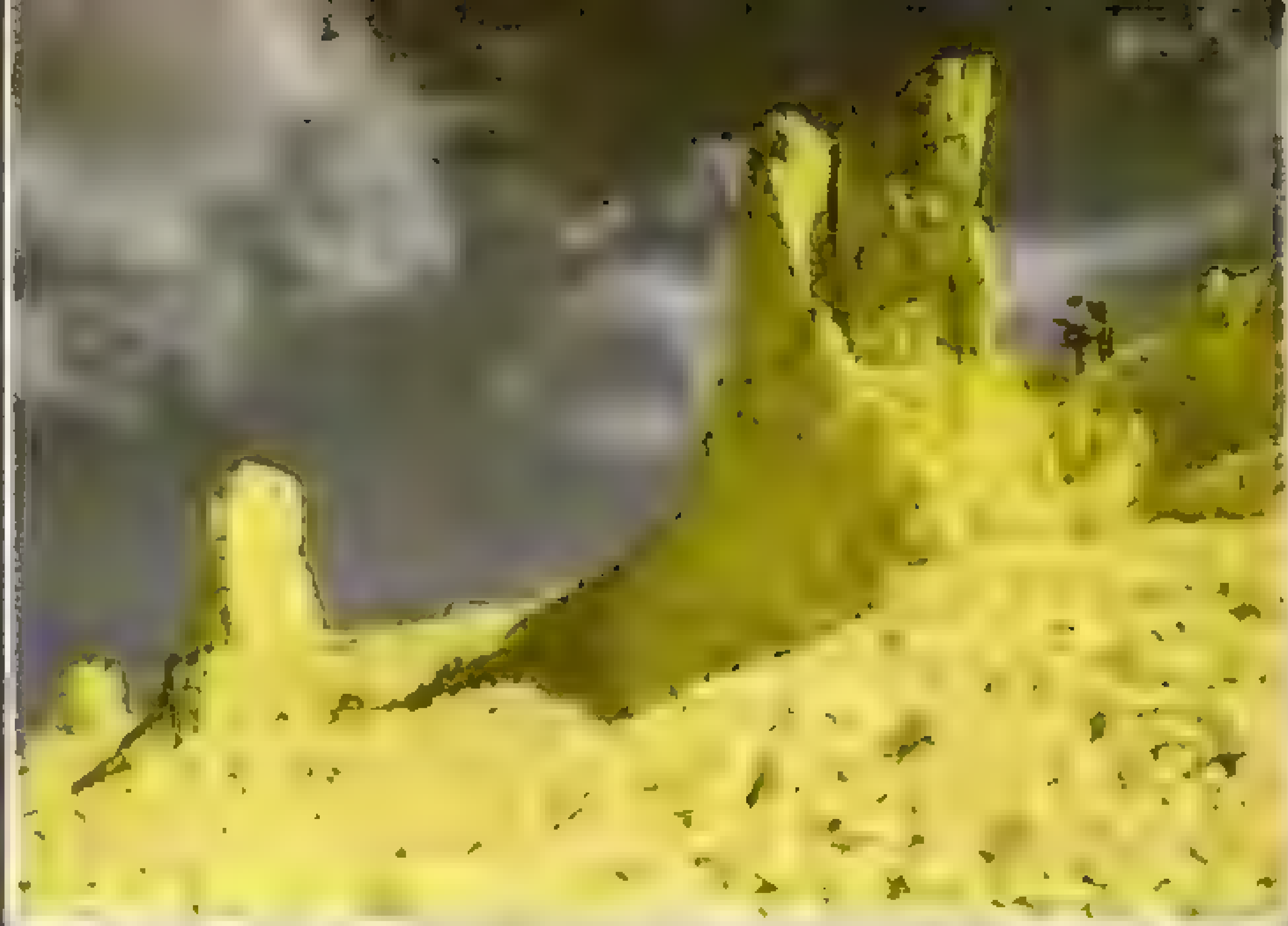
Molten sulphur spraying from a nozzle at a Grande Ecaille storage vat. Hotter than normally boiling water, the liquid is deposited evenly on top of the vat, where it will solidify into a mass that can be quarried as it is needed

STRANGE MINES TAP *Sulphur* FROM DEPTHS OF EARTH TO FILL ONE WAR NEED IN QUANTITIES TO BURN

By Alden P. Armagnac

GIGANTIC blocks of bright yellow sulphur, almost 100 percent pure, rise like plateaus from the flat countryside of Texas and Louisiana. Their combined bulk compares with the Great Pyramid of Egypt. Just as it stands, this means a 15-month supply for all our needs. And the 4,000,000-ton store simply represents above-ground reserves, constantly replenished as fast as they are torn down and consumed. Here is a refreshing contrast to some of our present shortages in other essential war materials.

Probably many people still think of sulphur only as something to be mixed with molasses for a spring tonic—or to be used in ointments and fumigating candles. That would overlook, for one thing, its tremendous importance to farmers as an insecticide. Dusted over cotton plantations from airplanes, for example, sulphur guards one of our greatest agricultural resources. Vulcanizing depends upon sulphur to transform soft and sticky latex, from rubber trees, into springy rubber for the tires of fast military vehicles and of airplane landing gear. Among latest applications, sulphur promises to excel sand as a filtering medium to remove sediment from water. And some of



As sulphur in the storage vat is broken down for removal, isolated pinnacles left standing are leveled by boring holes in them and blasting. These are remnants of a solid block 50 feet high, 250 feet wide, and a quarter mile long

the most corrosive chemicals flow harmlessly through pipes made of sulphur!

Chemical derivatives of sulphur, particularly sulphuric acid, consume by far the largest amount of brimstone or native sulphur. What steel is to the mechanical world, sulphuric acid is to the chemical industry. So devices resembling oil burners convert flaming, molten brimstone to acrid sulphur dioxide gas; a catalyst adds another atom of oxygen to yield sulphur trioxide; and this, with water, becomes highly concentrated sulphuric acid.

Smokeless powder, TNT, and fertilizers require this "king of chemicals" for their manufacture. It refines petroleum products, including the high-octane gasoline that is so instrumental in giving the United Nations' warplanes the edge on Axis craft. Sheet steel, sped through continuous mills for countless war needs, sheds its scale and receives a smooth bright finish in a pickling bath of sulphuric acid. Closer home, paint for our houses, dyes for our clothing, and rayon for many of our fabrics depend upon the chemical. Chemists say that the prosperity and civilization of a country can be measured by its output of sulphuric acid.

Cameras would be useless without photographer's hypo, another sulphur compound, to make the pictures permanent. In medicine, miraculous cures have been effected with the growing family of lifesaving "sulfa" drugs. Woolen blankets and socks become shrinkproof when treated with a recently developed sulphur chemical called sulphuryl chloride; another, sulphamic acid, serves as a fireproofing agent.

These highlights show why, according to recent figures, the United States requires two and a half times as much sulphur as copper; three and a half times as much as lead; four times as much as zinc; nine times as much as aluminum; and 30 times as much as tin. Fortunately, both literally and as a figure of speech, we Americans have sulphur to burn.

One of the strangest of mining methods has made this country the world's leading producer of sulphur. Sinking wells to extract a mineral as hard as rock, from depths of 2,000 feet or more, may border on the fantastic. But it works.

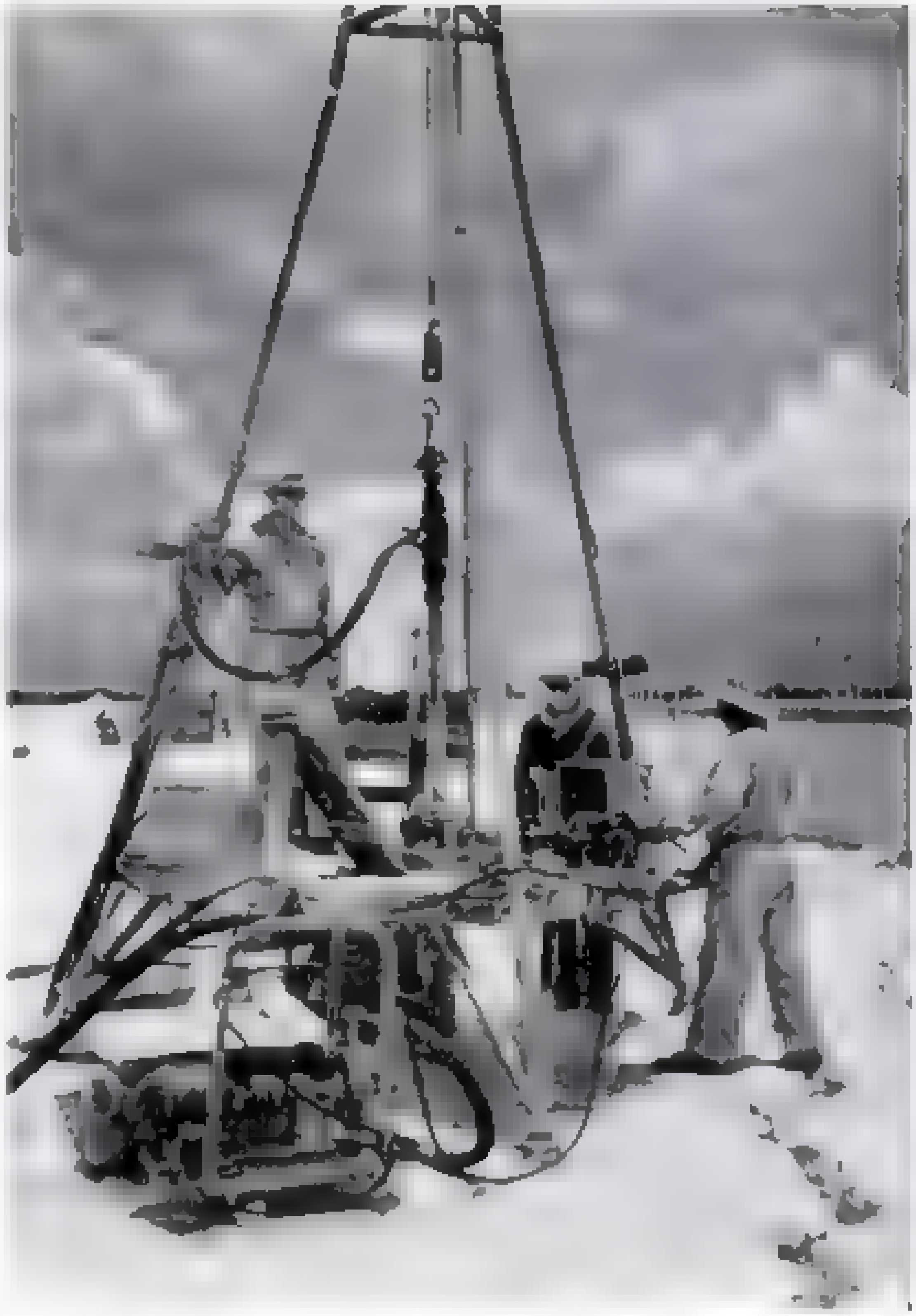
Once you know the trick, the principle seems simple. Sulphur melts at 240 degrees F.—not far above the normal boiling point

of water. Now, everyone who has a pressure cooker knows that water can be superheated, or boosted to a boiling temperature considerably above its normal 212 degrees.

Suppose, then, that you heat water under high pressure to as much as 315 degrees, and direct it through a vertical pipe to sulphur-bearing limestone far under the surface of the earth. Emerging through perforations near the lower end of the pipe, the superheated water spreads outward through the porous rock. The sulphur melts. Being heavier than water, the liquid brimstone collects in a pool at the bottom of the formation.

Insert a smaller pipe in the hot-water supply line, and the molten surphur will rise in it, forced upward by the water pressure applied to the deposit. Finally, add a central tube supplying compressed air, and the air bubbles will lighten the column of sulphur, so that the rising liquid may be drawn off into a collecting tank at the surface.

This is the method put to work today by the country's two major producers, the Freeport Sulphur Company and the Texas Gulf Sulphur Company, at their Gulf coast fields. Illustrations reproduced upon these pages, through their courtesy and that of O. Winston Link, who made the striking color photographs, show the fascinating process in action.



Drillers start the work of breaking up the huge, solid blocks of sulphur. Rotary machines bore blasting holes 12 feet from the vertical face and nearly to the bottom

From nozzles or swiveling spouts, each day's output of brimstone spreads evenly over the rising block or "vat," where it solidifies. As soon as one vat is finished, another is begun. Meanwhile, blasters begin quarrying the completed block with dynamite, and the scoops of locomotive cranes crunch into the mass thrown down, loading it into box cars for travel inland or into gondola cars for shipment to the docks. Since the beginning of submarine warfare, much of the brimstone has been diverted from coastal shipping routes up the East coast, and towed in barges via the Mississippi River and then sent eastward.

Behind American brimstone lies a romantic story—the tale of a wildcat oil well, of fool's gold, and of Dr. Herman Frasch.

The well, sunk away back in 1865 in Louisiana, never struck oil. But it did strike sulphur, as shown by samples brought up in drilling. There was good reason for Americans to get excited about it.

For more than a century, the brimstone mines of the Italian island of Sicily had enjoyed a world monopoly on sulphur, mined near the surface by simple shafts and tunnels, and brought to the portals in basketfuls on the heads of workers. Then the short-sighted Sicilian interests boosted prices to exorbitant heights.

Sulphur-hungry England talked war. Chemists in many lands sought substitutes. They found one in iron pyrites—more commonly known as fool's gold from the resemblance of its yellow luster to that of the precious metal. By roasting pyrites, they obtained sulphur dioxide for making sulphuric acid. But American pyrites were inferior to that of Spain. For either brimstone or its substitute, we had to depend upon imports.

Discovery of the Louisiana deposit promised freedom from foreign dominance of the sulphur market. True, the sulphur lay 450 feet underground, beneath a barrier of quicksand and swirling sulphurous waters.

Sectional view of the earth's crust, showing a typical sulphur formation above a "salt dome" and how it is tapped by main and auxiliary wells. Since petroleum also is found near "salt domes," oil exploration has uncovered important sulphur beds. Native sulphur and porous limestone form a mottled yellow-and-gray rock

Nevertheless, bold attempts were made to sink a shaft of 10-foot diameter, lined by cast-iron rings with waterproof joints, so that miners could go down and get the sulphur out. Every try failed. The last one cost the lives of several workers, overcome by sulphurous fumes, and the project was abandoned.

Then Dr. Frasch, with brilliant research in oil problems to his credit, entered the picture. He set up his own sulphur-mining invention—the original of the apparatus used today—and on his first try, in 1894, pumped more than 50 barrels of sulphur. Then the machinery broke down.

It took him eight more years to eliminate the "bugs" and make his process a commercial success. He learned to sink auxiliary wells, down which mud was poured, confining the hot water to the area being mined; and "bleedwater" wells to relieve excess pressure and prevent a blowout up the exterior of the sulphur-well casings. And he lived to see the Frasch process break the Sicilian monopoly and start America toward independence for brimstone. Up to its exhaustion in 1924, the site first probed by the wildcat oil well yielded a total of more than 10,000,000 tons of sulphur!

Since his time, 11 other sites have produced sulphur, of which five are currently operating. And experience has brought about numerous improvements of the hot-water process. One of the most important automatically regulates the temperature of the water as it goes down each well—for every well behaves like a prima donna, with a temperament all its own, depending upon the local structure of the deposits. On one property, a well balked at producing until the hot water was lowered just a little in temperature. For sulphur, as liquid as water at 315 degrees, becomes as thick as molasses at 330 degrees.

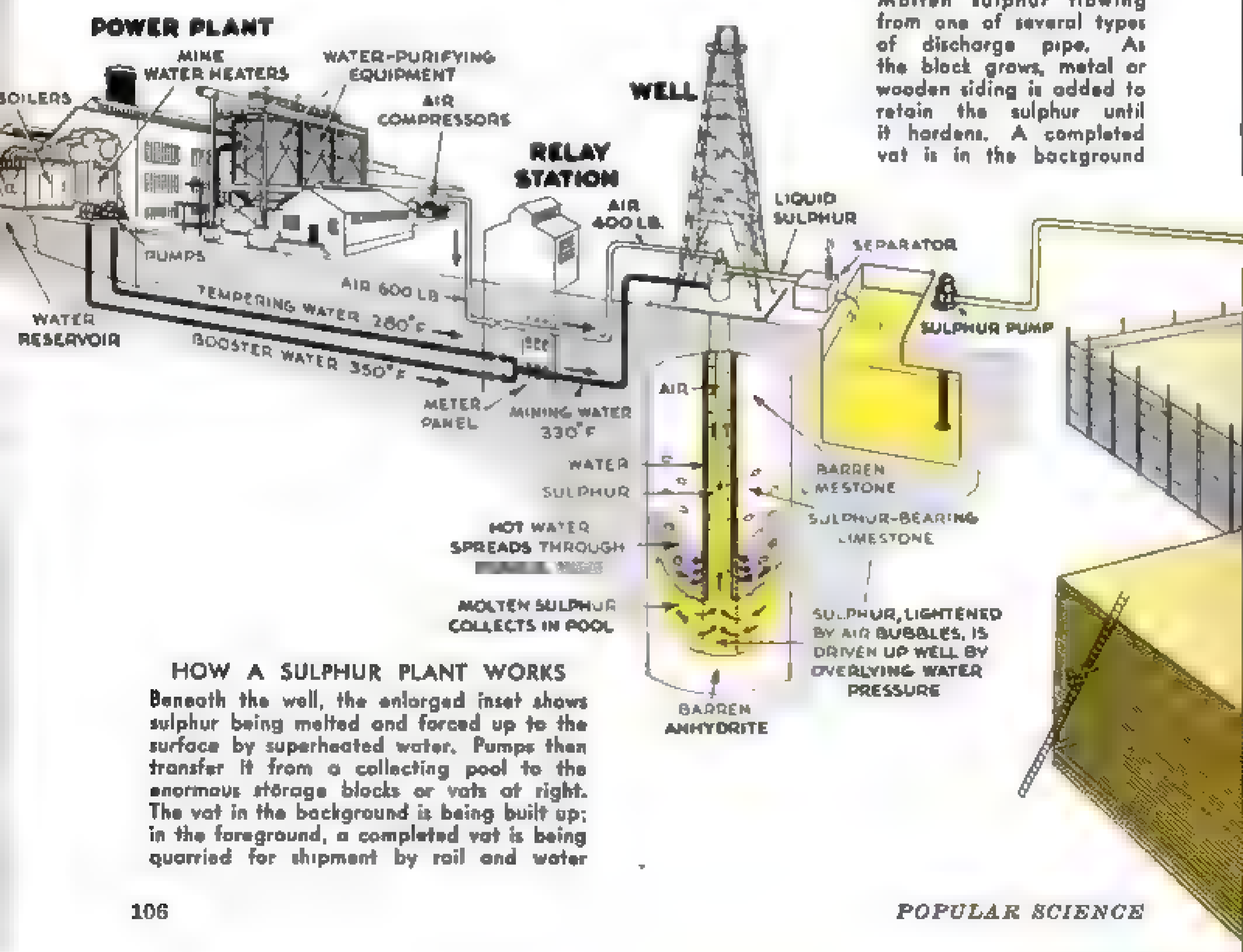
To assure uninterrupted supply, modern sulphur-mining men keep vast stores in piles above ground. Any one of a number of emergencies may compel a temporary shutdown. Operators have learned long since not to build power plants on top of a deposit being worked,

for removal of the sulphur produces cave-ins and damages boiler-house foundations. But the wells must remain, and a violent earth movement may break the pipes. Then new wells have to be drilled, while the stock pile reserves take up the slack.

During the last war, at a time when the United States was desperately short of sulphur, there came an inopportune moment when a 90-mile Louisiana windstorm practically razed the country's principal brimstone plant. By superhuman effort, some of the wells were restored to production in three weeks.

Such a crisis appears remote today, with big reserves supplemented by sulphur-saving chemical processes. In the last war it took 800 pounds of sulphur to make 1,000 pounds of smokeless powder or of TNT. Now 200 pounds of sulphur suffice for 1,000 pounds of smokeless powder, and only 30 to 40 pounds of sulphur for 1,000 pounds of TNT. That means all the more shells and bombs for us to dispatch to the proper places.

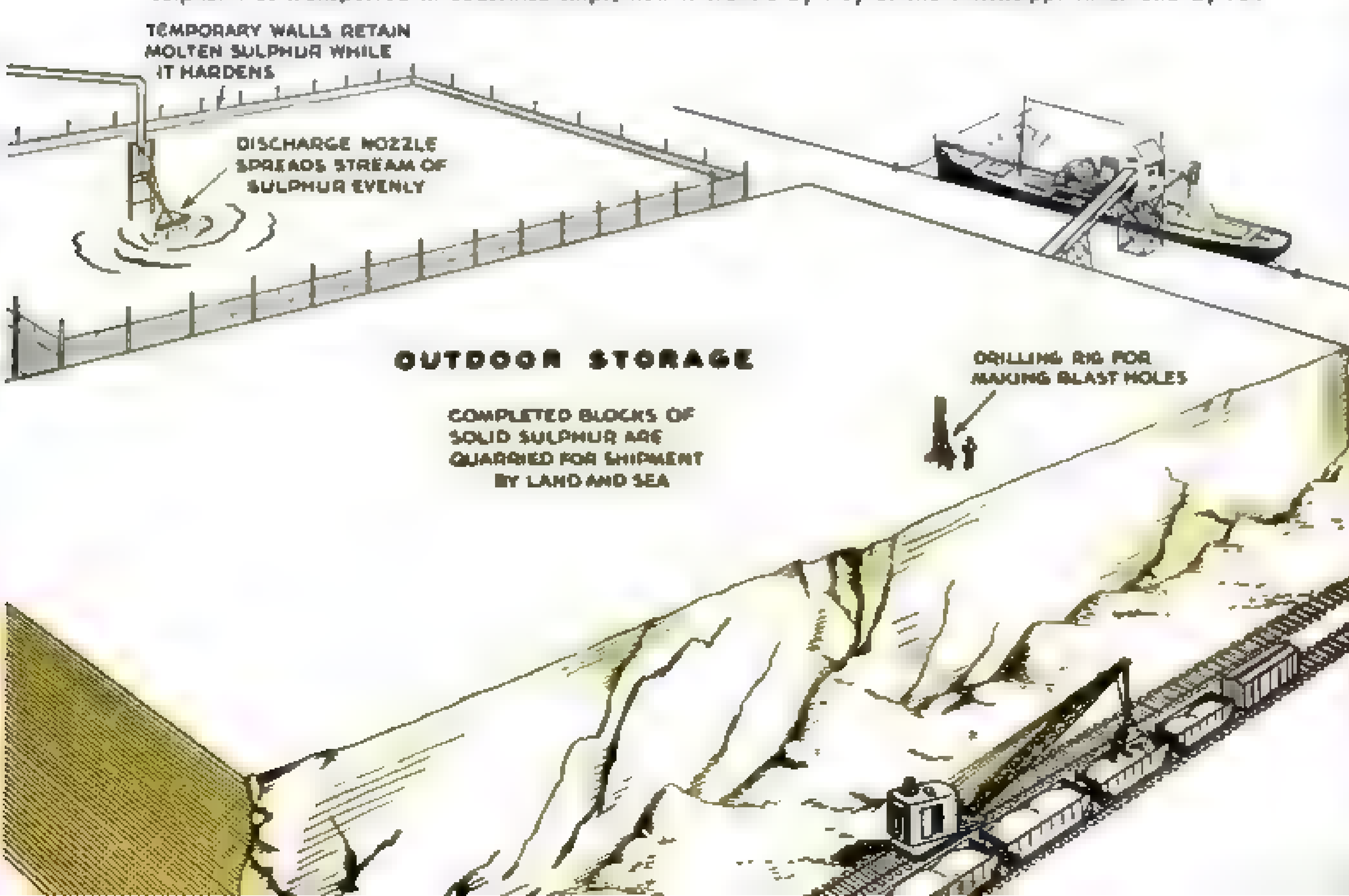
Molten sulphur flowing from one of several types of discharge pipe. As the block grows, metal or wooden siding is added to retain the sulphur until it hardens. A completed vat is in the background



HOW A SULPHUR PLANT WORKS

Beneath the well, the enlarged inset shows sulphur being melted and forced up to the surface by superheated water. Pumps then transfer it from a collecting pool to the enormous storage blocks or vats at right. The vat in the background is being built up; in the foreground, a completed vat is being quarried for shipment by rail and water

Here quarried sulphur is loaded on barges through a conveyor and hanging spout. Before the war much sulphur was transported in coastwise ships; now it travels by way of the Mississippi River and by rail



Do You Know This Plane?
Do You Know Its Performance?
Do You Know Its Size?
Do You Know Its Name?

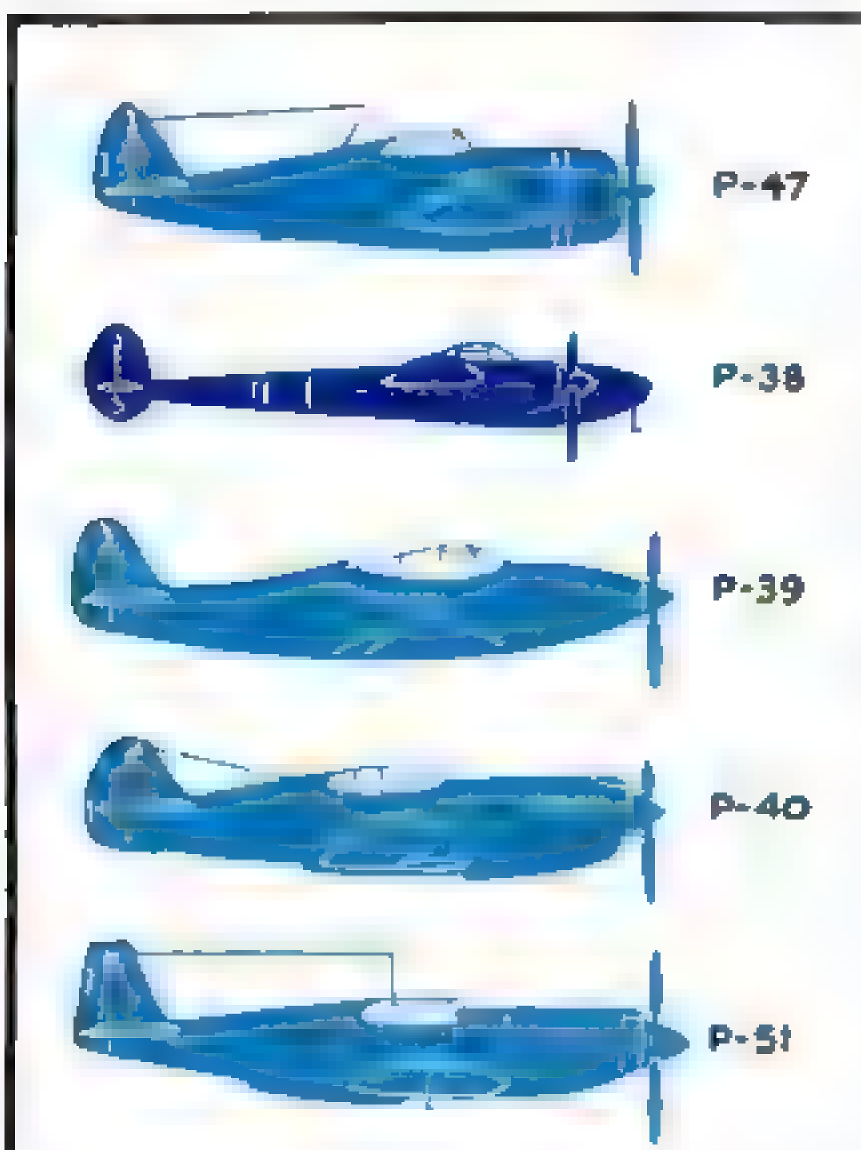
By WILLIAM S. FRIEDMAN

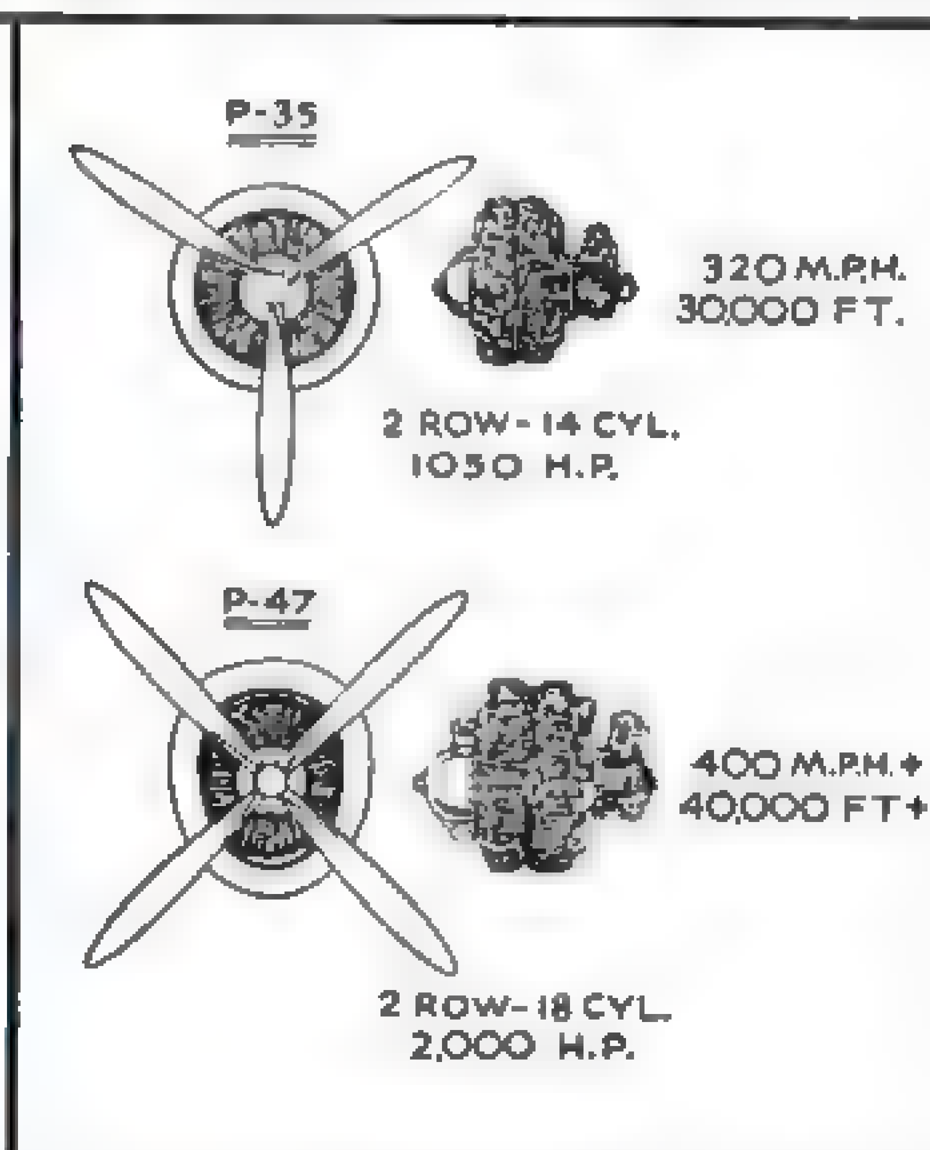
THOSE people who live with their ears glued to short-wave receivers and eat foreign war dispatches with their breakfast food can have their cereal with a little less than normal indigestion from now on. Herr Goebbels' microphones and mimeographs have been caught short by what is considered a medium-sized airplane plant on Long Island. It seems that the Nazi ministry of propaganda boasted in both broadcast and release that the Focke-Wulf 190, the Luftwaffe's new single-seater fighter designed by Kurt Tank, could dive down on anything currently flying, and fight comfortably at an altitude in which most contemporary types had to struggle to remain on the wing.

Then the bubble broke. A specimen of the FW-190 was captured intact in England. It was reconditioned, examined, and test-flown. Its performance was carefully tabulated and compared with current Allied types. One of the ships that showed up most consistently on the plus side of the score sheet was the

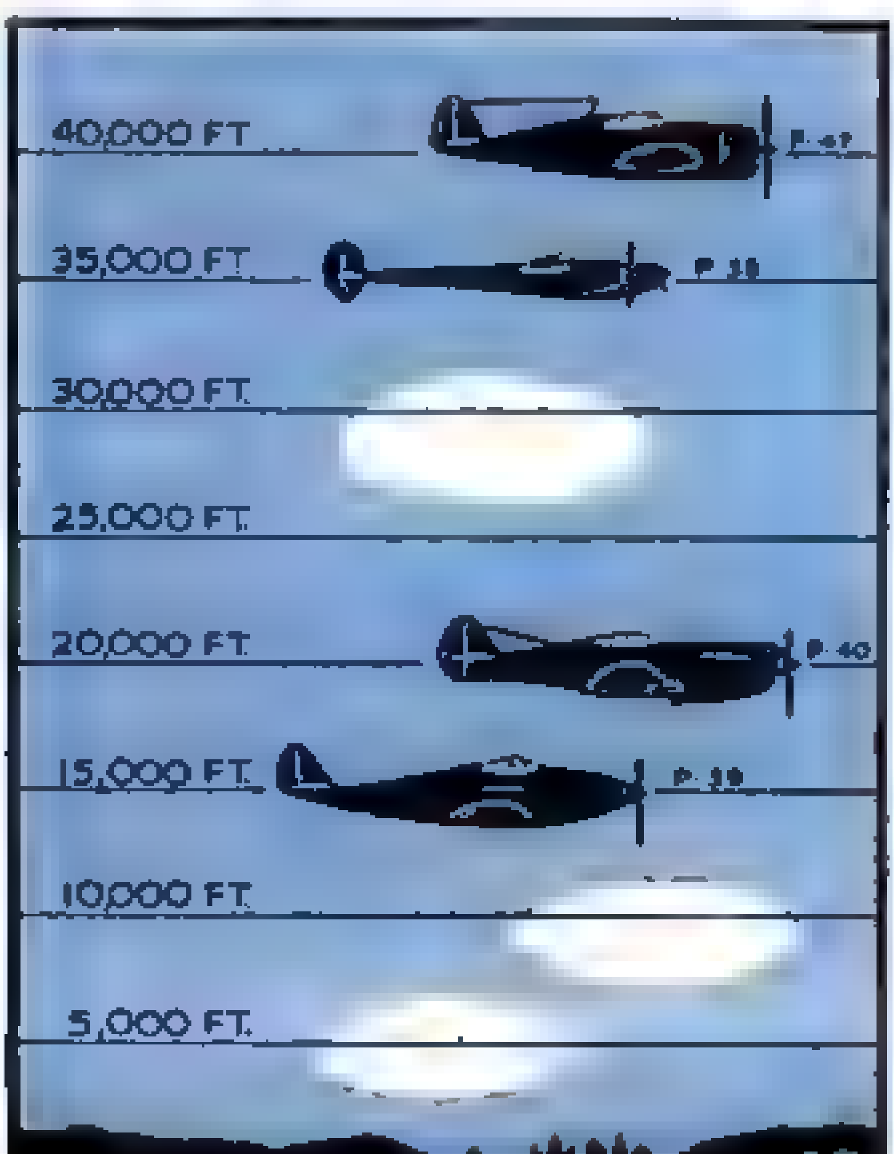
BLUNT, BULLDOG NOSE of the P-47 sets it apart from the needle-nosed silhouettes of the four other current fighters of the U. S. Army Air Forces. The reason is that it is the only one of the five that is powered by an air-cooled engine

LAST AIR-COOLED FIGHTER was the P-35. Since then, air-cooled engines were out because they couldn't develop enough power without excessive bulk. The 2,000-horsepower motor in the P-47 is no larger in diameter than the P-35's 1,050-horsepower

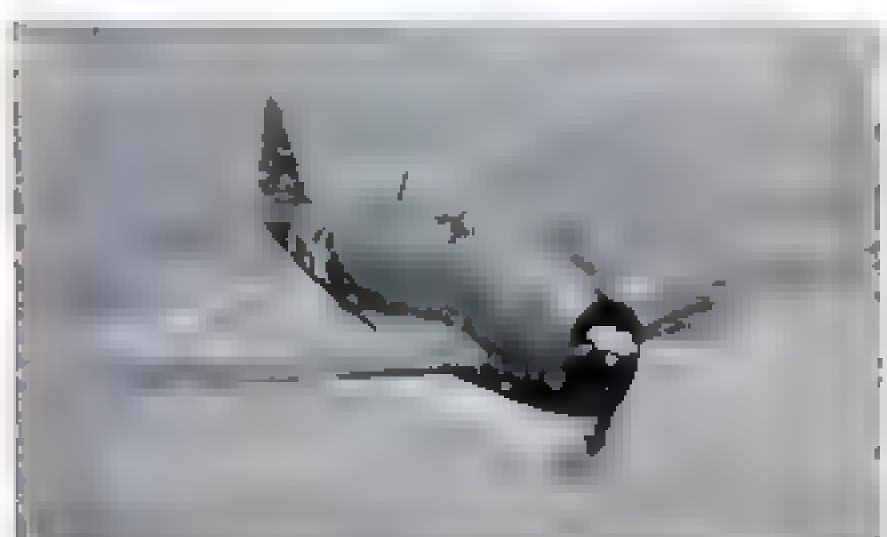




IT'S THE *Thunderbolt*



Three Thunderbolts in a row. With its "hot" flying characteristics, its smashing firepower, and, above all, its ability to operate efficiently at high altitude, it is one of the best of the Allied answers to the vaunted Focke-Wulf 190



It's no easy job for one man to fight and fly this fast-moving ship. To help him as much as possible, the utmost in automatic control is built into it

Diagram at left shows how the Thunderbolt's service ceiling compares with those of other U. S. fighter planes. It carries the air war up to a new level

Landing a "hot," heavy ship like this, especially on rough ground, calls for a wide landing gear. The result is to give the P-47 a decidedly bowlegged look on the ground. The retractable wheels are being drawn up at the right

Below, the operation of the hydraulic landing-gear mechanism is being explained to ground-crew mechanics. One plant is already nearing capacity production of P-47's, two more on the way

American-built P-47, Republic Aviation's Thunderbolt.

Affectionately known as "Gargantua," this design reverses many traditional ideas for fast, high-climbing, "hot"-performing military aircraft. Unlike the whippet-lined, needle-nosed ships that preceded it, the Thunderbolt resembles a bulldog head-on; the illusion being exaggerated by a wide, bowlegged landing gear, deep belly, and oval cowling face.

It's a big ship; probably the largest single-engined fighter in service anywhere. It has a 40-foot wing span, its fuselage is 35 feet long, and it stands 12 feet, 8 inches high, not including the propeller. Its landing gear spreads 15½ feet for excellent handling in rough fields.

Powered by a 2,000-horsepower Ford-built 18-cylinder two-row Pratt & Whitney turbo-supercharged engine, swinging a 12-foot four-bladed Curtiss-electric propeller, it can climb like a homesick angel; shoot like the devil with eight heavy-caliber ma-

"Gargantua," the pilots call her. A giant among fighter planes, the P-47 has a 40-foot wing span, a 35-foot fuselage, and a height of over 12 feet

HOW THE THUNDERBOLT COMPARES WITH ITS AXIS RIVAL

REPUBLIC P-47

WING SPAN	40 FEET
LENGTH	35 FEET
HEIGHT	12 FEET, 8 INCHES
WEIGHT (APPROX.)	13,500 LB.
CEILING	40 000 FEET (PLUS)
SPEED	400 M P H. (PLUS)
POWER	2,000 H.P. (FORD BUILT PRATT and WHITNEY)
FIREPOWER	8 FREE-FIRING MACHINE GUNS (

FOCKE-WULF 190

WING SPAN	37 FEET
LENGTH	31 FEET
HEIGHT	11 FEET, 5 INCHES
WEIGHT (ESTIMATED)	10.200 LB
CEILING	43 000 FEET
SPEED	370 M P H. AT 18 000 FEET
POWER	1,700 H.P. BMW ENGINE
FIREPOWER	4 15-MM. RHEINMETAL-BORSIG CANNON

chine guns, and fight at any altitude the pilot can endure.

At the Republic plant, the type is approaching capacity production. Shortly it will be joined by two more factories, one of which is currently building another design, the other a totally new plant. By spring, enough Thunderbolts should be flying to force the level of battle into the 40,000-foot-and-over sky strata.

The P-47 was born of two ghost airplanes. One of them got to the mockup stage, the other one died on paper. By early 1940 the Army's current Republic, the P-43, showed signs of being outdated. War conditions dictated such changes as increased power,

"This plane is regarded as a tremendous package of power and is believed able to outfly and outfight any other known airplane. It carries enough guns to generate at maximum firing speed an impact equal to the force of a five-ton truck hitting a brick wall at 60 miles per hour."

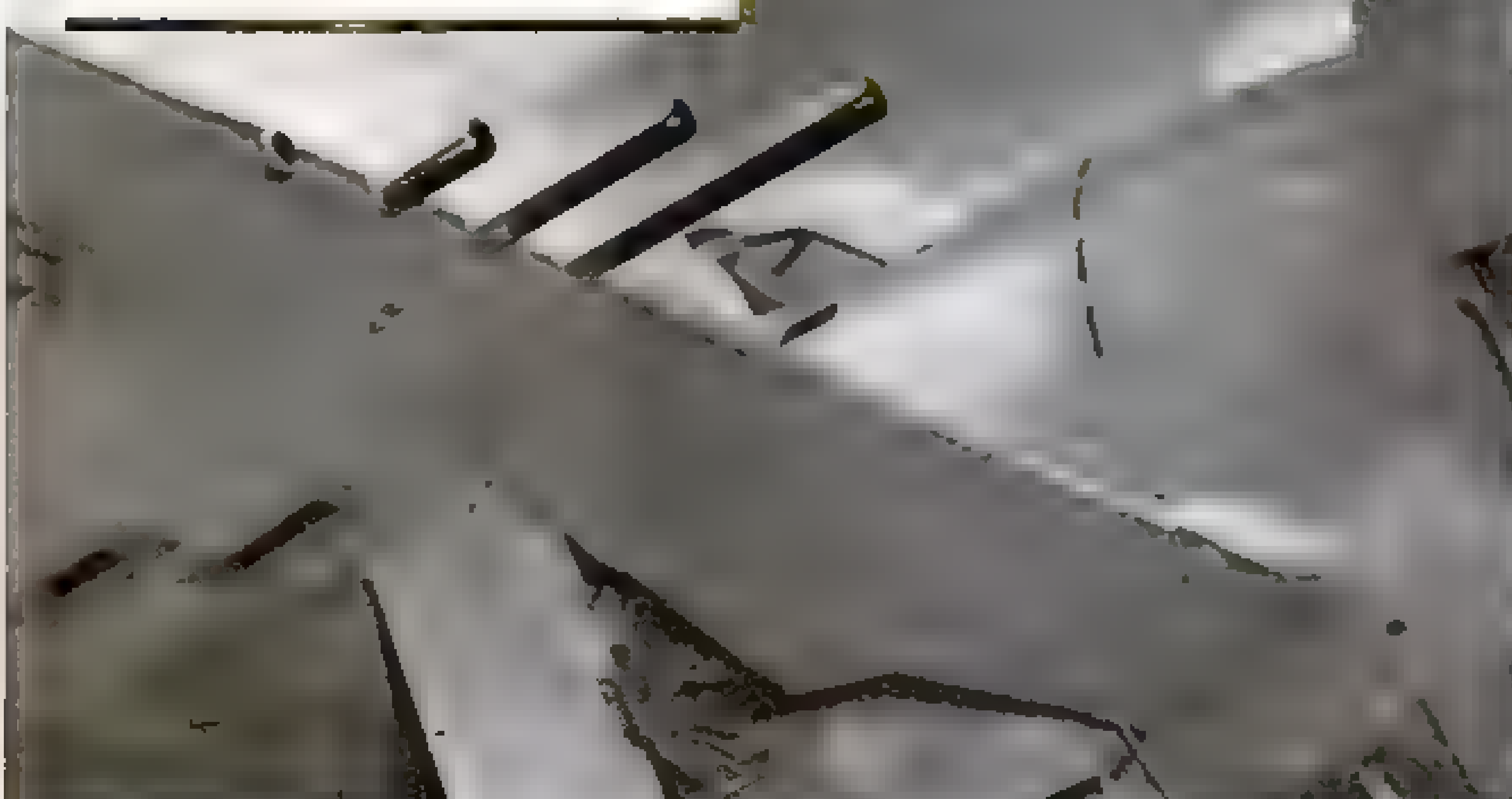
LIEUT. GEN. HENRY H. ARNOLD, Commanding General, Army Air Forces

higher service ceilings, increased firepower, armor, and self-sealing tanks. The P-44, an evolutionary successor, had been designed. Over $800,000 had been spent on design, engineering and research. The mockup, or full-scale wooden model, was nearly complete. All the needed changes—a 1,350-h.p. engine, six guns, armor, etc.—had been incorporated. That was late summer, 1940.

Alexander Karteveli, Republic's vice president and chief engineer, and Hart Miller, head of the Army Sales division, went to Wright Field, Ohio, the headquarters of the U. S. Army Air Forces Matériel Division, to discuss specifications on the P-44 and a projected craft, the XP-47. The latter was to be a center-engined, liquid-cooled experimental single-seater and was still in the drawing and discussion stage.

After completing their business, Kartevell and Miller were dining with several Wright Field pilots and engineers. The usual "hangar flying," (aero slang for "bull session") began over coffee and cigars. The subject swung around to the ideal single-seater. There is a persistent tendency for every pilot to think he can out-design the plane designer. This particular group, for a change, really could have done it. "Now if I were designing this ship. . ." Ideas followed, half-reasoned reactions of test pilots, never yet put on paper. Radical notions

Eight free-firing, heavy-caliber machine guns—four staggered into each wing—enable the plane to strike like one of nature's own thunderbolts. Some idea of the wallop is conveyed at the left



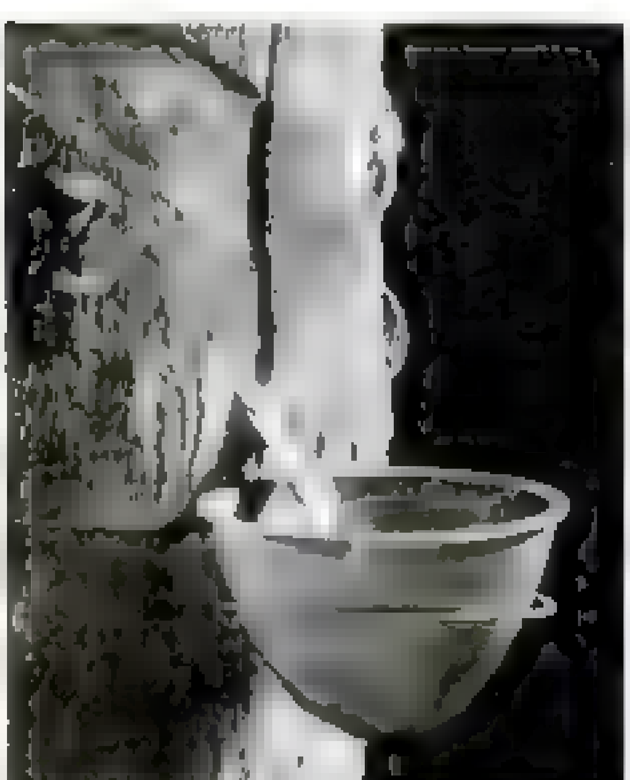
taken from still unrecorded observations from the frontier of high-speed, high-altitude flying.

Almost unnoticed, Karteveli took notes on the back of a dog-eared envelope. When he and Miller returned to Long Island the following day, they scrapped the P-44 and the million dollars she had cost, sought Government permission to abandon the XP-47A and concentrate on the new type. Permission was granted. In order to cut red tape, the new ship was given the unbuilt freak type's serial number and was built as the XP-47B. The war was close at hand. There was no time for such time-consuming luxuries as mockups. Aside from a miniature wind-tunnel model, the first (Continued on page 226)

That "dropped jaw" look apparent in a head-on view—one of the P-47's outstanding characteristics—is due to a big air scoop under the engine. New, the cowling is a variation on the NACA cowling

Plastic Rubber-Sap Cups Make Saps of Native Souvenir Fans

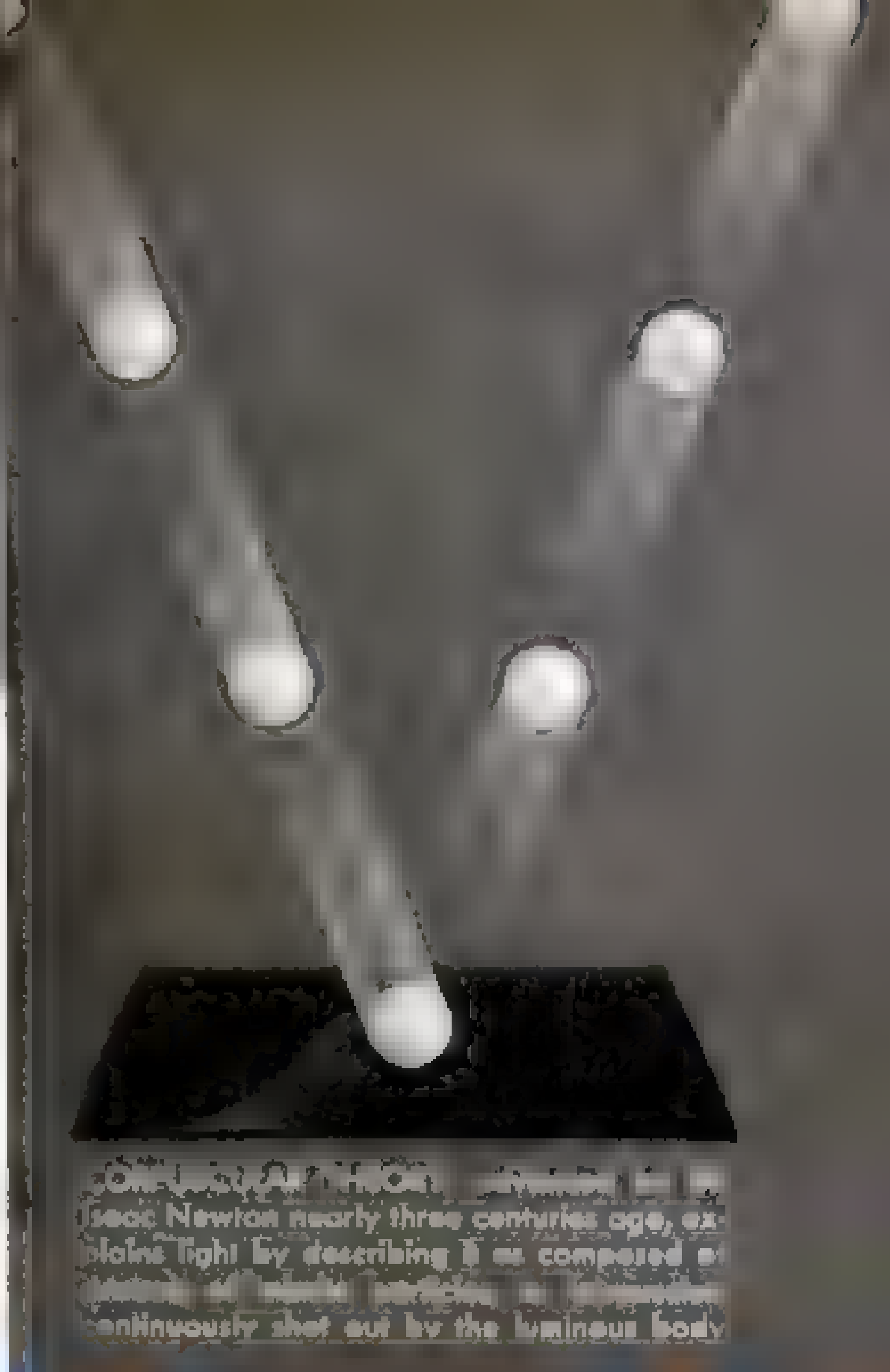
TO DISCOURAGE Brazilian natives from removing sap-catchers from rubber trees on its South American rubber plantations, the Ford Motor Company is now making the cups of plastic. Indians had discovered that the metal cups formerly employed made excellent drinking cups and other household vessels if the ends were flattened. They will find that the new Tenite cups do not lend themselves to this treatment. Since the old cups were of aluminum, there is an additional reason for the change of material.

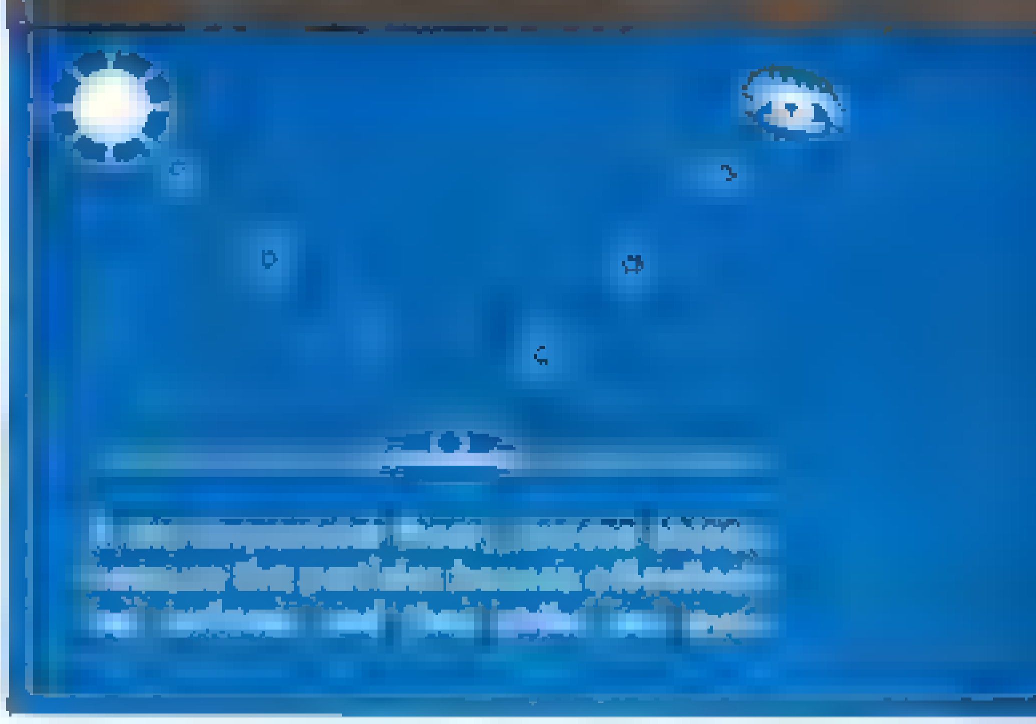


Precious latex drips into a plastic cup on a rubber plantation in Brazil. At right, cups come from a molding machine in a Ford plant

Light Control —The Secret of Modern Optics

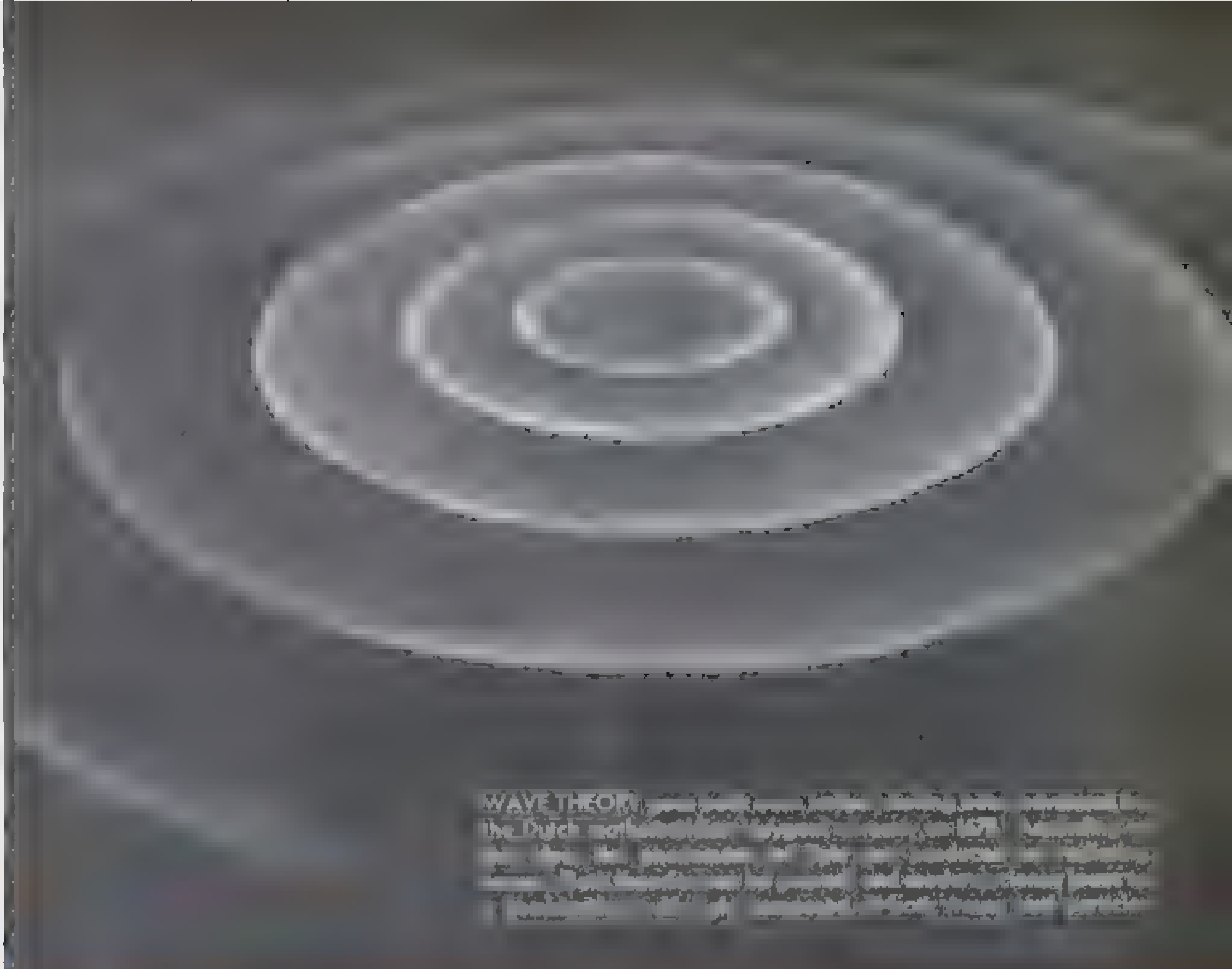
By HERBERT ASBURY





AN AVERAGE man, quoting his dictionary, probably would define light as the opposite of darkness and let it go at that. But the modern physicist or optical scientist might describe it as part of an unbroken series of electromagnetic rays, transmitted by the undulatory or vibrational motion of the ether, and traveling in all directions through space at the extraordinary velocity of 186,000 miles a second. All of these rays obey the same natural laws, but differ in two main respects—in frequency, or the number of vibrations in a given unit of time, and in wave length, the range of which extends from waves hundreds of miles long to waves so incomprehensibly short that millions of them could be crowded into one inch. Man is visually aware of only about one sixtieth of the electromagnetic rays which science has so far explored. That small portion we call light, and earth's share of the total amount of light sent out by the sun is approximately one part in more than 2,000 millions. But if paid for at the rate of one cent a kilowatt hour it would cost $500,000,000 a second.

The normal human eye is primarily tuned to wave lengths of 0.000055 centimeters, but it can respond to wave lengths ranging from about 0.00004 to 0.000075 centimeters, or about 1/30,000 to 1/60,000 of an inch. This range comprises the visible spectrum, and within these narrow limits man finds all the light and color of his tiny segment of the universe; actually he looks at creation through an exceedingly narrow slot. The color of the light that he sees is governed by its wave length, and varies from violet at the short end of the spectrum, through green and yellow at the middle, to which the eye is most sensitive, to red at the long-wave-length end. Beyond the visible spectrum, on the short-wave-length end, are the ultraviolet waves and the X rays, the gamma rays emitted by radioactive atoms, and the radiations which are associated with cosmic rays; on the long-wave-length end are the infrared (heat) and radio waves. Owls and other nocturnal animals can probably see to some extent with infrared radiation, and occasionally a human being is found who can see light waves shorter than those of the visible spectrum. But in general the eye is blind to waves shorter than violet or longer than red.



To speak of light as waves is not to dismiss or disprove the corpuscular theory, which was first promulgated by Sir Isaac Newton almost three centuries ago. A wave theory of light was outlined as early as 1678 by the Dutch mathematician Huygens, but Newton's prestige was so great at that time that it was generally dismissed as unsound. Eventually, however, the wave theory was adopted, and Newton's idea that light was composed of streams of particles fell into the discard. Today, however, the physicist believes that light is both waves and particles called photons, tiny packets shot out by atoms and molecules and carrying the energy of light. Both theories can be proved. Some types of experiment clearly demonstrate the wave nature of light, while others show its corpuscular nature just as clearly. To the lens designer it makes little difference.

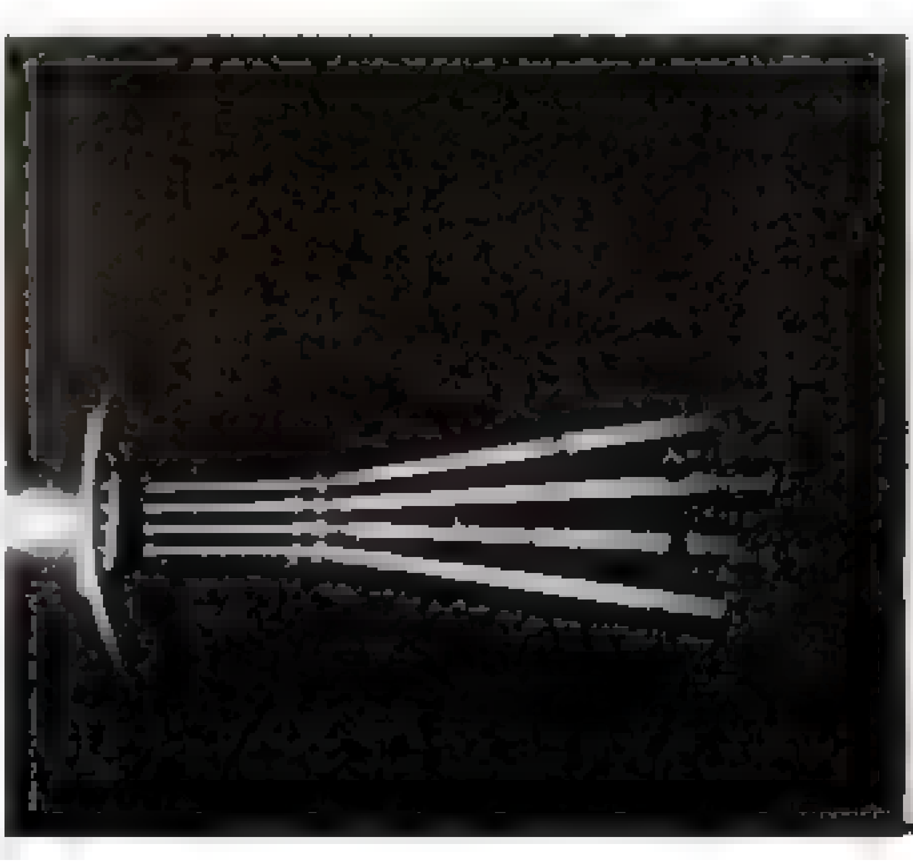
The light of the visible spectrum is controlled, and certain of the invisible wave lengths are either eliminated or utilized,

LENSES AND PRISMS are the principal tools with which man controls light and makes it work for him. In the photograph above are shown a few of the lenses and prisms manufactured by the Bausch & Lomb Optical Co. for use in modern optical instruments

by means of chunks and sheets of glass, ground and polished into lenses and prisms. With them the optical scientist applies the various natural phenomena which govern the behavior of light, and, according to the phenomenon employed and the method of application, he can gather light, condense its volume, bend it, isolate its different colors, separate and measure its wave lengths, and change its speed and direction. The most important of these phenomena, without a knowledge of which modern optical science would be impossible, are:

1. *Refraction*, or the bending of light waves, the most widely applied of all the phenomena of light. It is used in all spectacle lenses, and in nearly all telescopes, projectors, binoculars, and other optical instruments. Refraction occurs when light passes obliquely from one medium to another in which its velocity is different. This change in speed causes the constituent wave lengths of the light beam to bend by different amounts, depending upon their length, the density of the invaded medium, and the degree of obliquity of the surface. The commonest example of refraction is the stick which appears to be bent when thrust into water. Actually it is the light waves which are bent because water is denser than air, and so reduces the velocity of the light by about 45,000 miles a second. The index of refraction is described scientifically as "the number which expresses the ratio of the sine of the angle of incidence to the sine of the angle of refraction." In other words, a number which precisely defines the light-bend-

REFRACTION OF LIGHT by lenses and prisms is made visible by the Hartl Optical Disk seen at the left. The white lines passing across the face of the instrument show what happens when axial rays pass through a convex lens with a fairly good focus. Note how the emergent beams converge. Below is the result when a concave lens is used; here the emergent beams diverge



ing power of a particular piece of glass or other medium, and tells the optical scientist how hard it is for the light to get through.

2. *Dispersion*, or the separation of light into its different colored rays, arising from their different refractive capabilities. All kinds of light travel through the air at about the same speed, but when the rays strike a glass surface the different colors are bent by different amounts because some are slowed up more than others. Violet light, for example, travels through glass 5,000 miles a second slower than red.

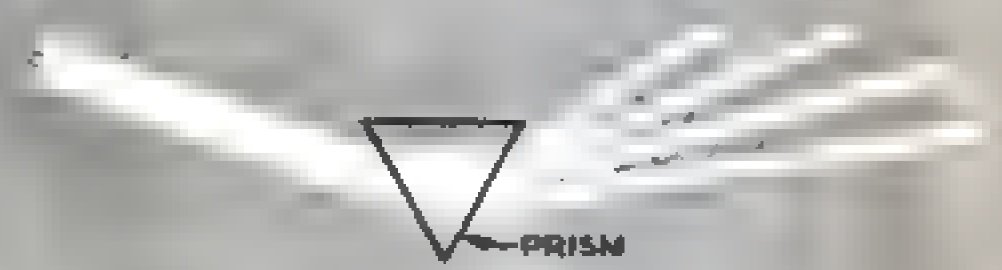
3. *Interference*, or the mutual influence of two beams of light. Under certain conditions, this phenomenon will produce colored fringes, dark bands, and darkness. Without it the optical scientist would be unable to test surfaces. It forms the basis of the interferometer, the machine which proves the wave theory of light and is used to measure stellar diameters.

4. *Polarization*. Ordinary light is unpolarized because its waves vibrate in all directions. It is polarized when it is sent through a material which filters out the horizontal vibrations, gives the vertical vibrations a definite direction, and admits only a part of the light. This phenomenon has been known to optical science for more than a century, but only in recent years has it been applied industrially, in such common and well-known usages as sun glasses and camera filters. Used in an instrument called a polarizer, it can detect internal strains in glass. Originally the best known polarizing agents were crystals of calcite and tourmaline. Today a better polarizer is made of plastics, manufactured in sheets by the Polaroid Company of

REFRACTION BY A PRISM is illustrated by the Hartl Optical Disk in the picture below. Observe that part of the rays are reflected from the first surface encountered. This is the type of prism used in producing a spectrum. Reflecting prisms, which reflect all the rays, are used in binoculars to obtain the effect of a long telescope tube by twice reflecting the rays of light received from the object

SEVEN WAYS LIGHT IS CONTROLLED

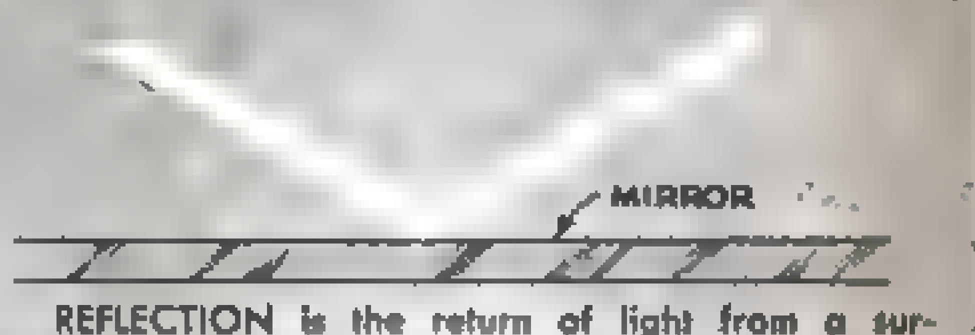
REFRACTION, the bending of light rays, is the most commonly applied phenomenon of light. It occurs when light passes obliquely from one medium into another in which it has a different velocity



DISPERSION is the separation of light into its different colored rays, owing to their different refractive abilities. The various rays are bent by different amounts because they are slowed unequally

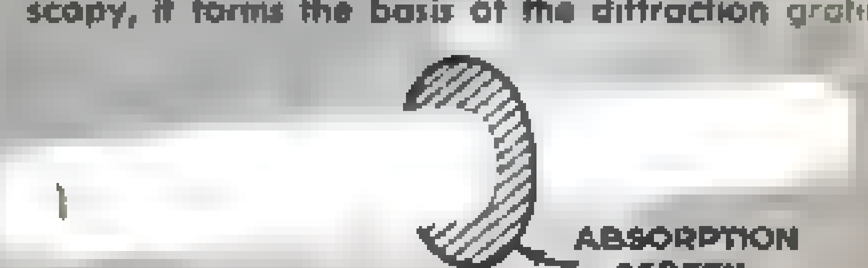
INTERFERENCE, the mutual influence of two beams of light, is the basis of the interferometer. Under certain conditions, this phenomenon will produce colored fringes, dark bands, even complete darkness

POLARIZATION. Ordinary light has waves vibrating in all directions. Polarizing filters out horizontal vibrations, gives others one direction



REFLECTION is the return of light from a surface. It is used chiefly in mirrors, searchlights, and those types of binoculars that contain prisms

DIFFRACTION, or the bending of light rays around the edges of obstacles, is a nuisance when it interferes with refraction. However, in spectroscopy, it forms the basis of the diffraction grating



ABSORPTION is the capture and retention of the radiant energy of infrared and ultraviolet rays. It finds practical application in protective lenses such as welding glasses and glasses for sun or snow

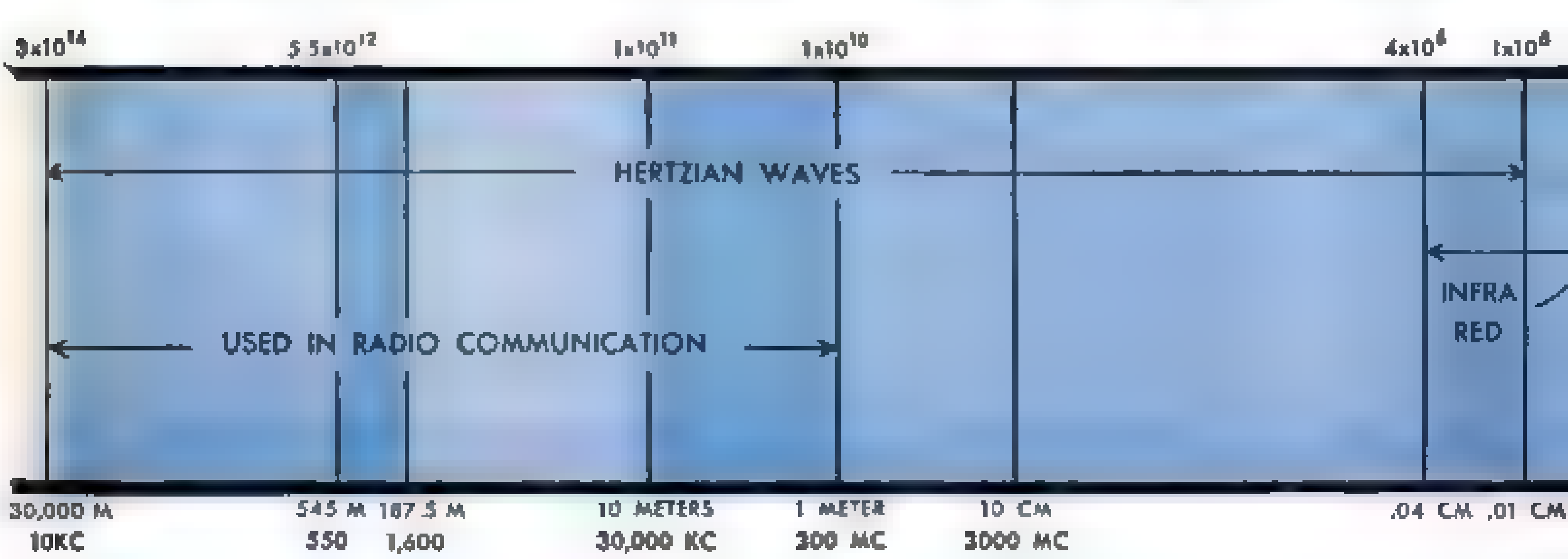
Crown glass (upper block, above) yields in refractive power to a new rare-element glass developed by the Eastman Kodak Company. The pencil appears more "bent" by the lower block. At right, a research worker removes an experimental melt from the furnace

America for a wide variety of applications.

5. *Reflection*, or the return of light from surfaces. Most reflection is only partial, because some of the light is absorbed, but total reflection occurs when the light, passing through a denser medium into a rarer, strikes the surface of the latter at an angle less than the critical angle. Reflection is used chiefly in searchlights, mirrors, and binoculars which contain prisms.

6. *Diffraction*, or the bending of light waves around the edges of obstacles. This phenomenon is associated with all wave motion, and increases in effect with the wave length. Optical scientists look upon diffraction as a nuisance, because it limits microscopes, upsets lens calculations, and interferes with refraction. Its chief use is in spectroscopy, in which it forms the basis of a sort of light-sieve called a diffraction grating. This is a highly polished mirror on which parallel scratches, spaced about 30,000 to the inch and numbering as many as 200,000, are scratched with a diamond. A diffraction grating can be used with light waves of almost any length, and sorts them into spectrum lines without the aid of lenses. The position of these lines can be established within 1/25,000 of an inch, and light waves can be measured to within one-billionth the thickness of a human hair. The chief disadvantage of a diffraction-grating

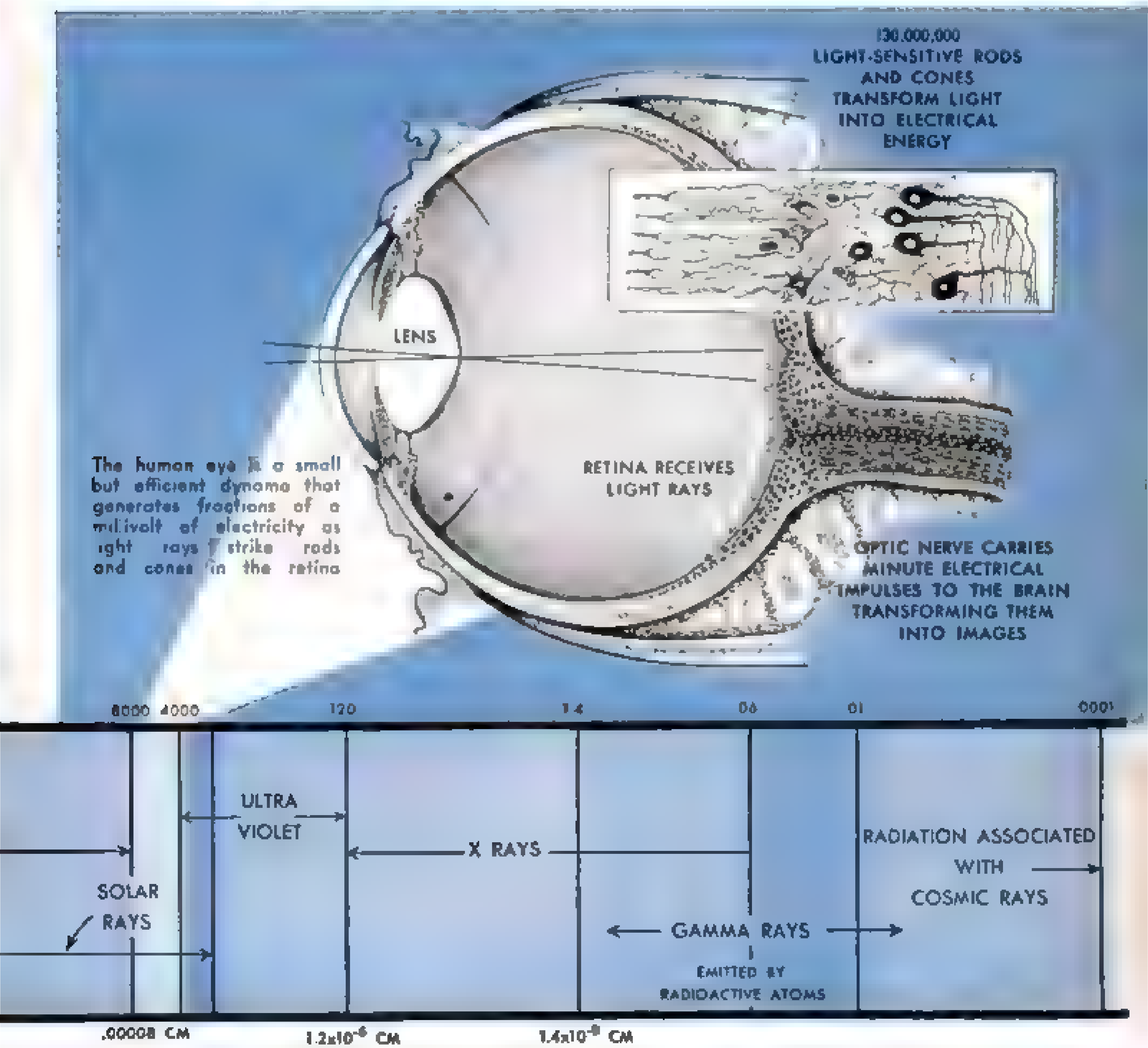
Spectrum of radiation so far explored shows the narrow slit through which man views his world. Outside the light spectrum on one side are the Hertzian waves used in radio; on the other, the X rays, gamma rays, and cosmic rays. The Angstrom unit of wave length is a hundred-millionth of a centimeter



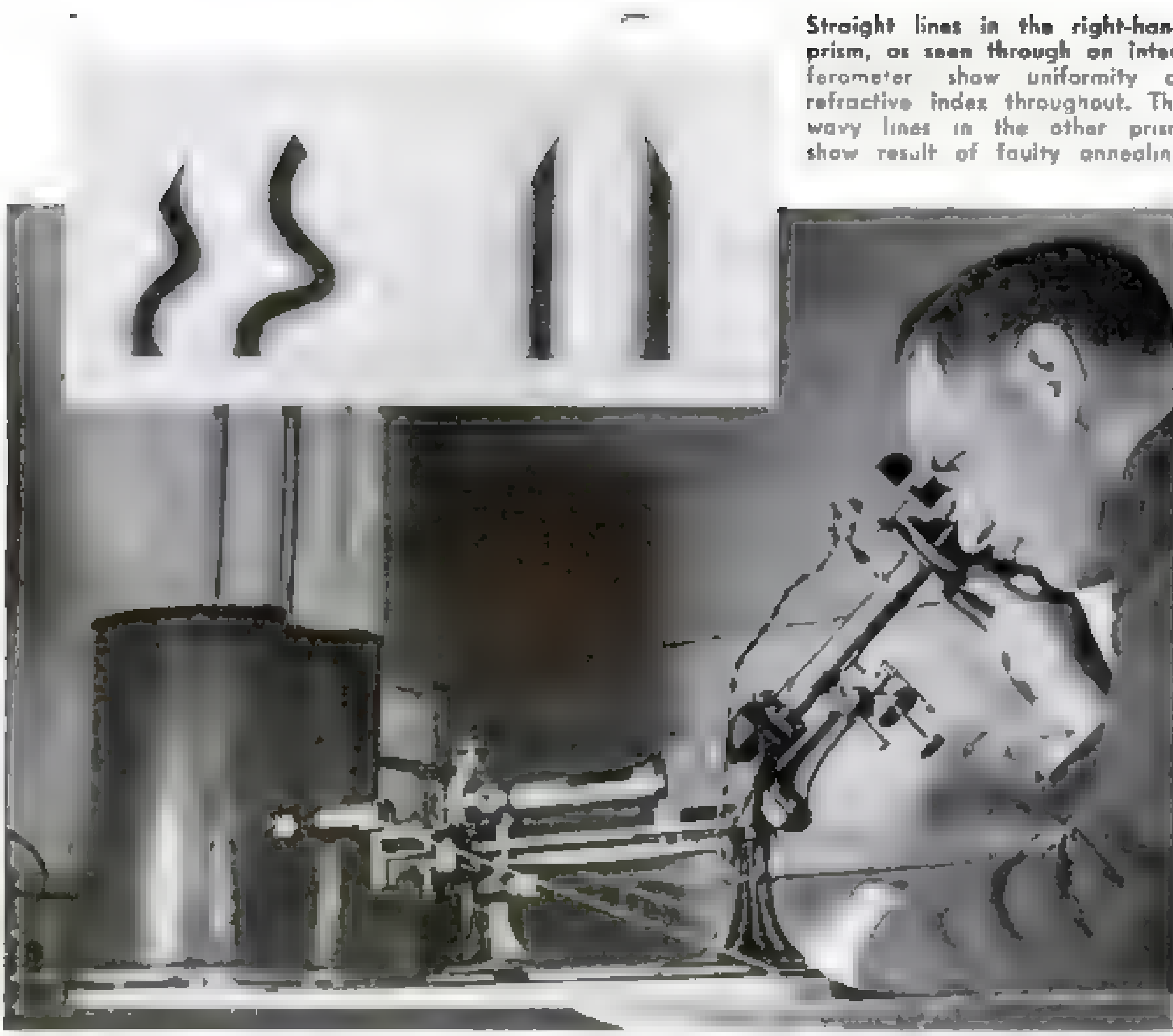
spectroscope is its size—it has to be housed in a huge room that is free from vibration.

7. *Absorption.* This phenomenon is valuable in spectroscopy as a means of detecting and measuring infinitesimal quantities of materials, but as far as optical science is concerned its application is limited to the capture and retention, by means of lenses, of the radiant energy of ultraviolet and infrared. It is used chiefly in ray filters, welding glasses, and sun and snow glasses, and protective lenses of other types. Research work in connection with absorption is now more or less confined to welding glasses because of their increasing importance in war manufacturing. These glasses are rapidly approaching perfection, although science has yet to solve the problem of controlling infrared, visible light, and ultraviolet independently. But the American Optical Company has developed a lens, designed especially for use in carbon-arc welding of extreme power, which transmits only 3/10,000 of the visible light, none of the ultraviolet, and less than .01 percent of the infrared. For acetylene and light electric welding, lenses are available which eliminate all of the ultraviolet and 99.9 percent of the infrared, and transmit 7/10 of the visible light.

Glass used for the application of these controlling phenomena is divided into two main classifications—optical glass for instruments and ophthalmic glass for spectacles—which in turn are subdivided into many types, each possessing a different combination of optical properties. The principal constituent of these glasses is silica in the form of sand, but the optical values depend upon the proportion in which various elements are added to the sand and such glass-making oxides as boron, barium, and boric and phosphoric acids. The elements commonly used include lithium, mag-



The human eye is a small but efficient dynamo that generates fractions of a millivolt of electricity as light rays strike rods and cones in the retina



Straight lines in the right-hand prism, as seen through an interferometer show uniformity of refractive index throughout. The wavy lines in the other prism show result of faulty annealing

The superior prism at right, above, is a product of the new annealing technique developed by Dr. E. D. Tillyer, research director of the American Optical Co. The instrument shown here in use is a spectrophotometer, which is used to measure transmission of light through a transparent medium such as glass

nesium, zinc, antimony, cerium, erbium, lead, silver, mercury, bismuth, uranium, and fluorine.

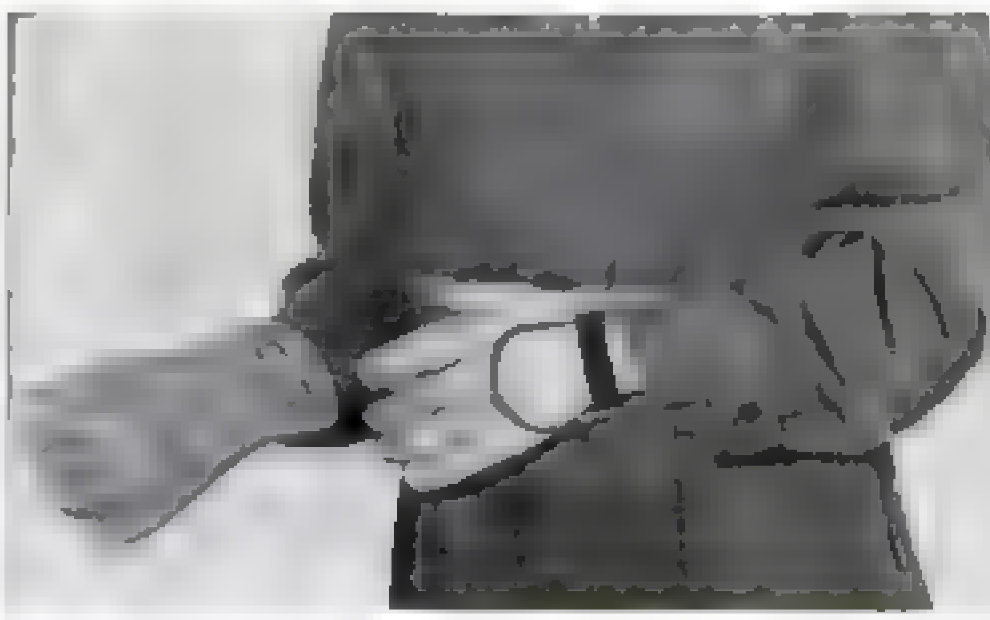
At every stage in the manufacture of both optical and ophthalmic glass great care must be taken to prevent the introduction of foreign matter into the melt. A trace of iron, for example, will ruin an entire batch. To guard against this manufacturing disaster, the milled clay of which the pots are made is run over a magnetic separator, and as a further precaution steel shovels are no longer used to shovel the sand. It was found that iron atoms scraped from the shovels were affecting the transparency of the glass. However, there is such a thing as too much purity. Silicate glass made of absolutely pure sand will dissolve very slowly in water, and to prevent this dissolution and stabilize the glass, alumina is added to the melt. In former years enough alumina was obtained by absorption from the pot, but with the introduction of larger pots and with changes in manufacturing methods, the quantity absorbed was found to be insufficient. To be acceptable for spectacle lenses, ophthalmic glass must now survive eight hours' exposure to dripping boiling water without loss by solvent action.

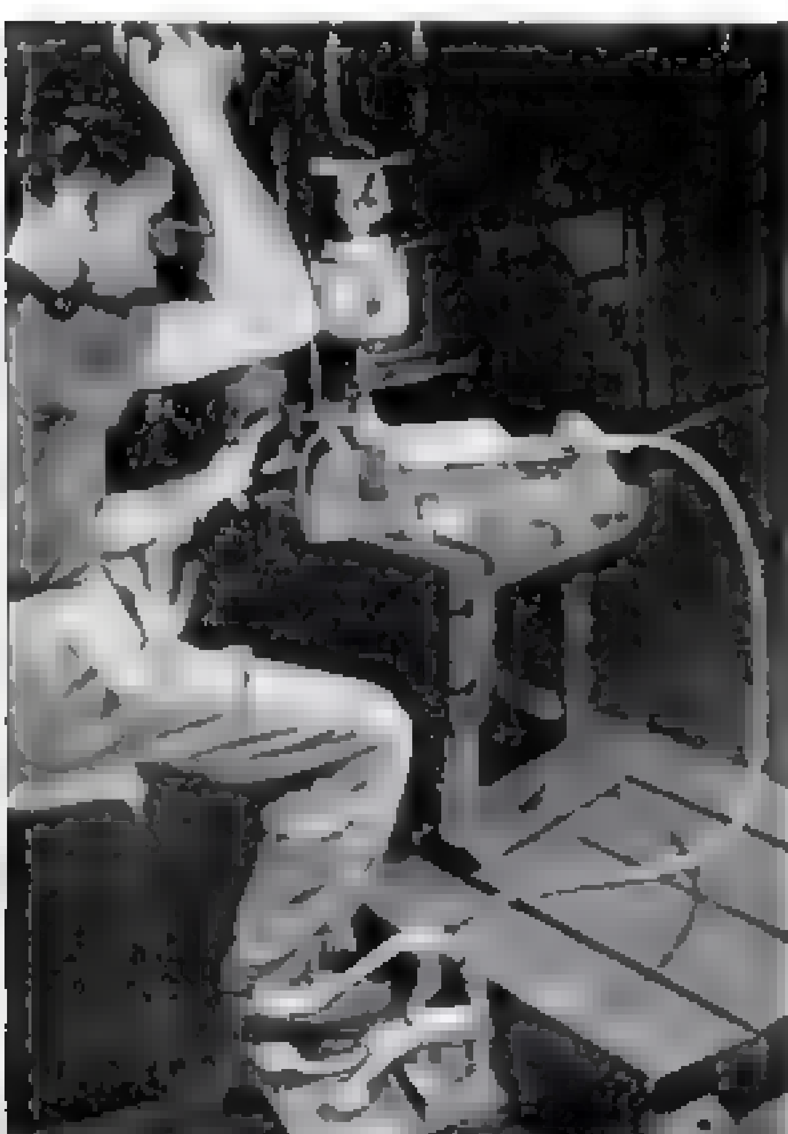
The manufacture of optical and ophthalmic glasses properly begins in the research laboratories of such companies as American Optical, Spencer Lens, Pittsburgh Plate Glass, Bausch & Lomb Optical, Eastman Kodak, General Electric, and the Radio Corporation of America. At these and other plants experiments are constantly in progress—American Optical alone makes more than 1,000 experimental melts a year—under the direction of scientists who are striving to achieve greater control of light by developing new glasses, by testing changes in the proportion of ingredients possessing known optical values, and by devising improvements in manufacturing methods. Out of these experiments have recently come *(Continued on page 222)*

new Tools

MAGNIFIERS for bench work, small-parts assembly, close inspection, and precision machining are available in various models. The one shown at right has a four-inch lens, mounted on a bracket so that it can swing over a wide area. Extra lenses, as well as other mountings, can be obtained.

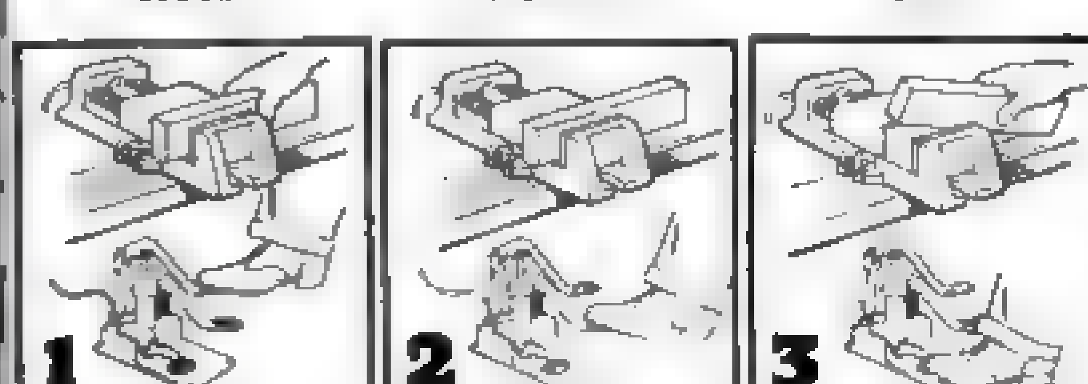
WOMEN'S WORK GLOVES with plenty of sturdy wear built into them are being worn by the well-dressed girl on the production line these days. The ones shown here are of flexible horsehide, with an open back for coolness. An elastic web band across this opening keeps the gloves snug. Extra toughness is added by a patch on the thumb and first two fingers. A protective two-inch band of leather covers the wrists. The gloves can be purchased singly as well as in pairs.





HYDRAULIC VISE. The machinist or toolmaker is free to use both hands in the operation, set-up, and removal of work held in the grip of this foot-controlled and hydraulically operated tool. Depressing the middle pedal at the hydraulic foot control base moves the rear jaw toward the stationary front one. Downward strokes on the right, or booster, pedal step up pressure to a maximum of 10,000 pounds per square inch. The left pedal releases the work. Many jobs can be handled in this way without bolting or clamping to the machine table. A safety factor is the absence of pressure snaps or uncontrolled movements of the jaws. The vise weighs 74 pounds.

CLOSE TIGHTEN OPEN



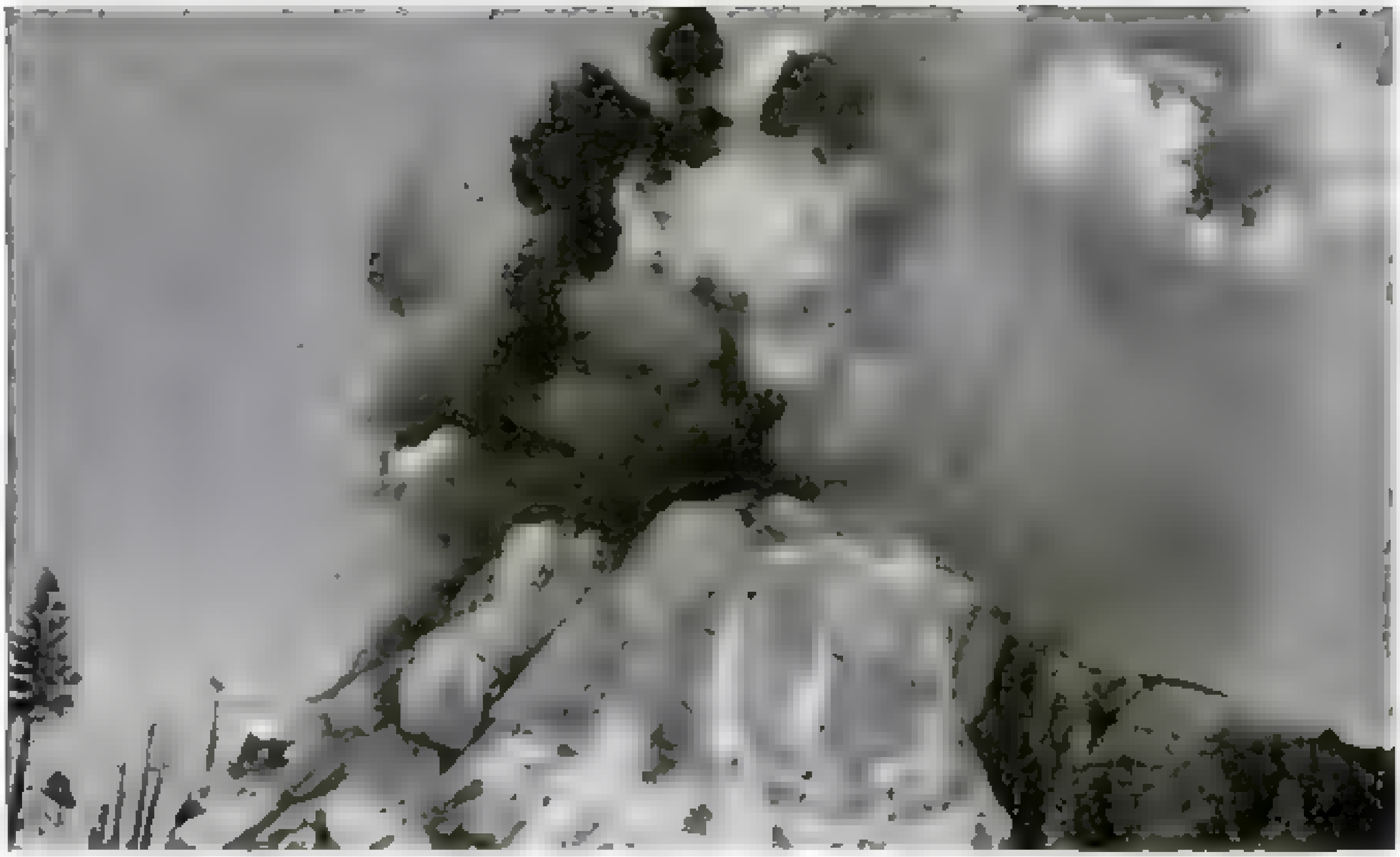
What the television actor sees: cameras, microphone boom, and lights trained on a set in the studio of Station WRGB, Schenectady

Television Program Gives Housewives Hints from P. S. M.

AMONG the programs with which WRGB, the General Electric television station at Schenectady, N. Y., is carrying on its regular schedule of eight hours a week, is a 15-minute skit called "Home Hints from Popular Science." In this program, the material for which is all taken from the Home and Workshop Department of P.S.M., a housewife beset by mechanical difficulties is rescued by hints remembered from this magazine. In a typical program she took a nail out of a door jamb without marring the wood, removed the base of a broken light bulb without cutting or electrocuting herself, and performed other feats.

This puppet introduces the program "Home Hints from Popular Science," a regular feature on WRGB's schedule. Below, the harried housewife, played by Martha Brooks, is reminded by Narrator Douglas McMullen that hints found in Popular Science solve her mechanical problems

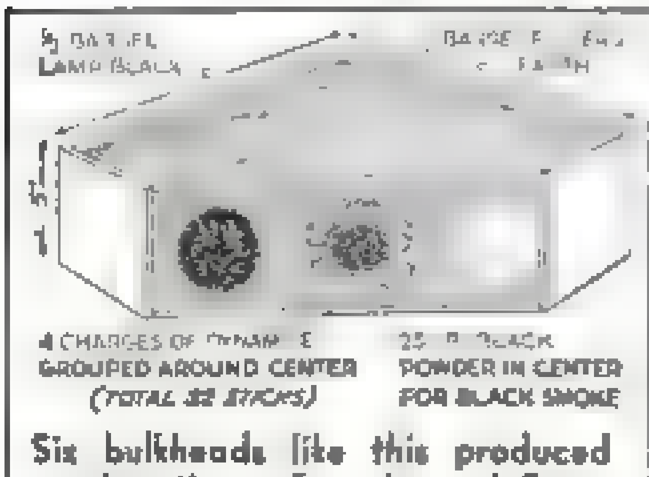
One of the hints: Using a cork to remove a broken-off electric-light bulb from its socket without cutting the fingers or getting a dose of current



A carefully blended explosion in "For Whom the Bell Tolls." Black powder makes black smoke, flash powder white flame. Fuller's earth settles at right, while chunks of cork and pulp fill the air at the left

DYNAMITE and POWDER PAINT MOVIE SCENES

WHEN Hollywood uses explosives, the purpose is not destruction but the creation of striking visual effects for the camera. And that's the job of Russ Brown, Paramount effects specialist, who has been painting screen pictures with dynamite and powder for 15 years. When called upon recently to provide for aerial-bombing sequences in "For Whom the Bell Tolls," he developed a new method of blending explosives and colors to produce any type of explosion desired. In one breath-taking scene, reproduced in the still at the top of the page, the summit of a mountain near Sonora, Calif., was wreathed in smoke and flame as carefully prepared charges were detonated in six bulkheads scattered about the peak.



Six bulkheads like this produced combinations of smoke and flame

For smaller blasts, the dynamite was put in holes and covered over with powder

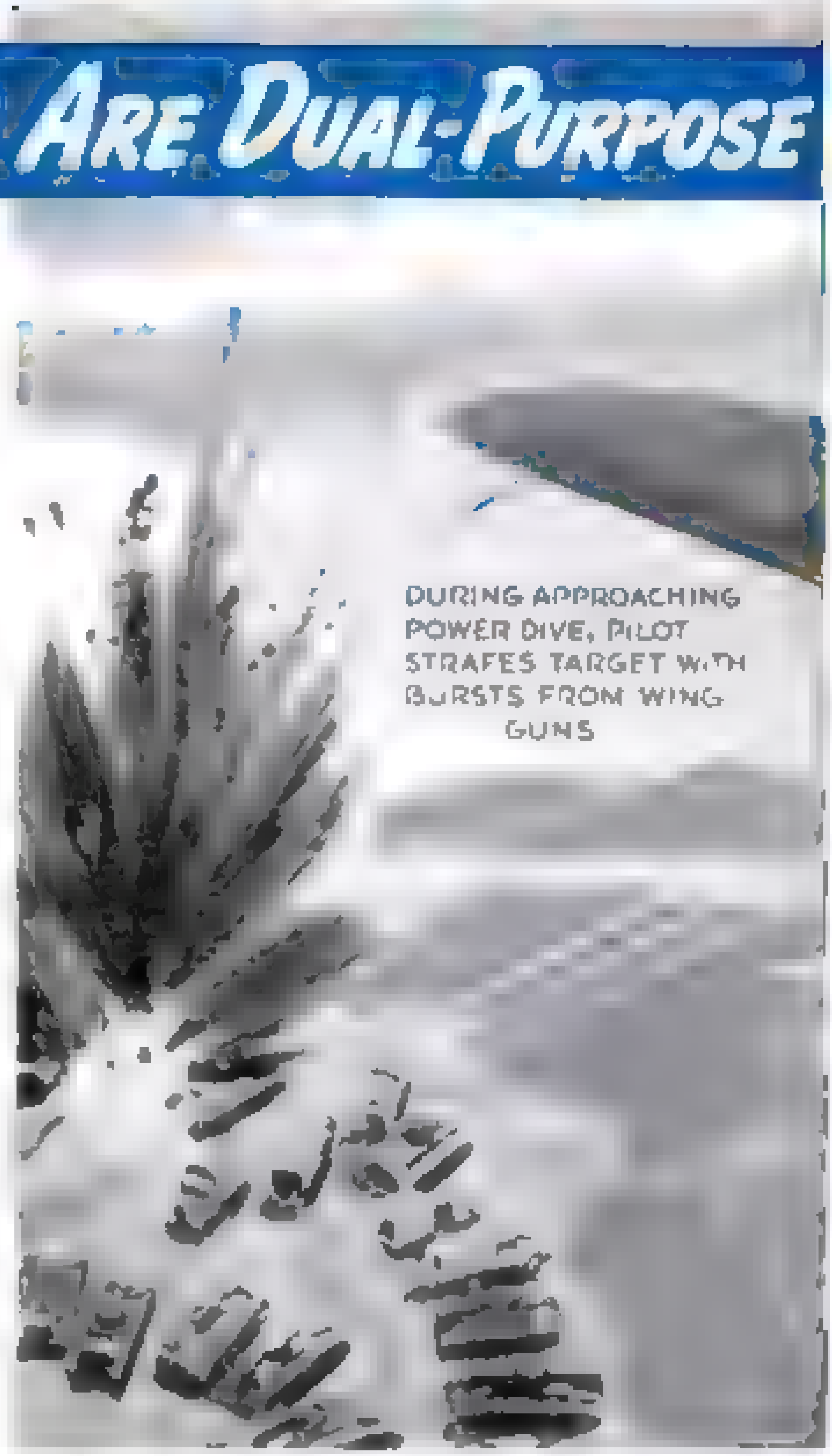
Ready to throw the switch. The drawing at the left shows how the charges were prepared in the six bulkheads, and also in narrow-cone craters

FIGHTER-BOMBERS ARE DUAL-PURPOSE

A NEW type of bomber is making more and more appearances with the United Nations forces. It is the fighter-bomber, and tactically it is fast winning its bid to outclass the dive bomber.

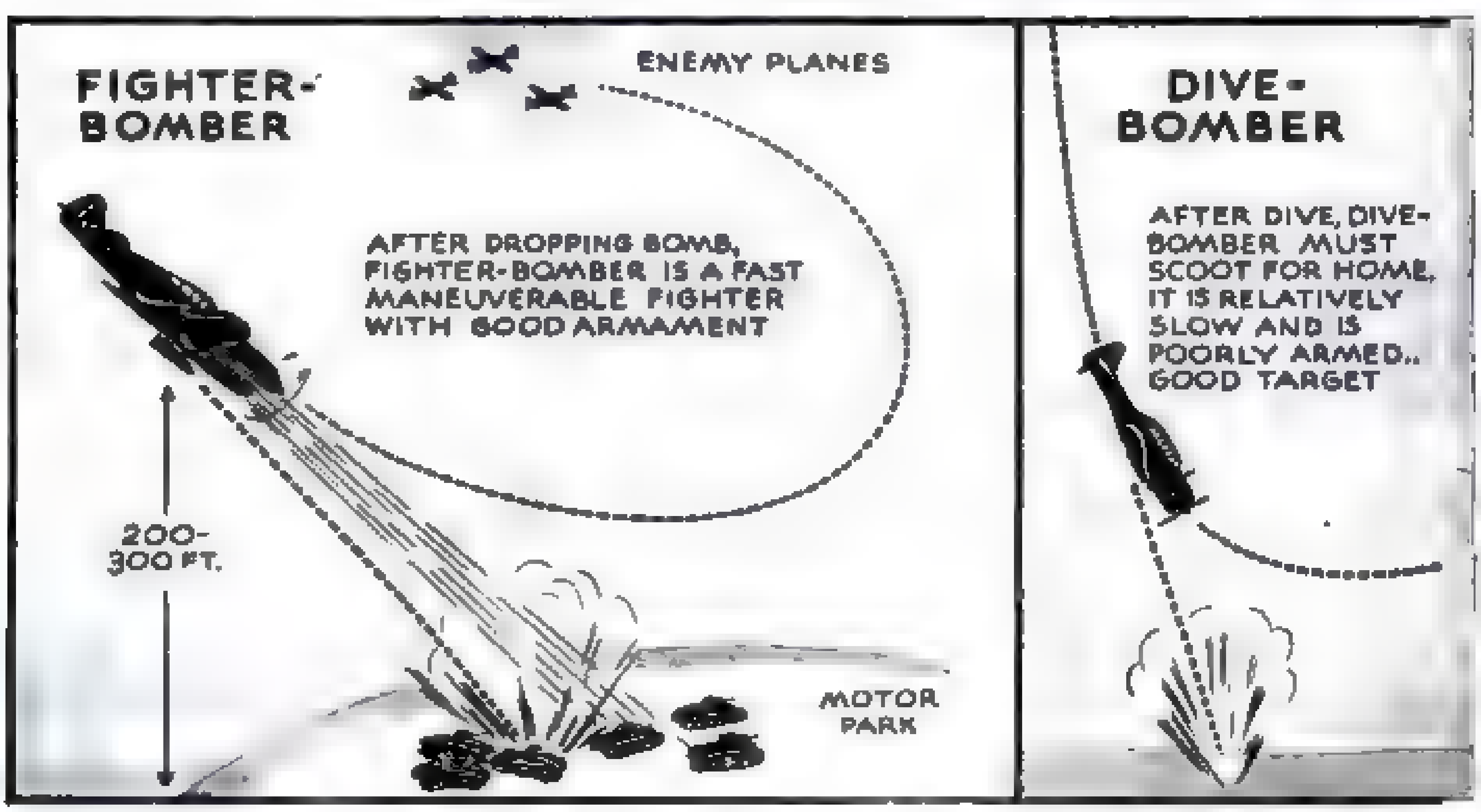
The fighter-bomber is a regulation pursuit ship fitted with an under-fuselage mounting for carrying a 500-pound delayed-action bomb. After dropping its load at the end of a shallow power dive, the fighter-bomber becomes a speedy well-armed pursuit ship, able to climb and maneuver and use its high fire power against enemy planes. Compared with the dive bomber it is faster, better armed, and presents a smaller target for antiaircraft installations, while its delayed-action bomb, leaving the plane with the speed of the power dive, hits its objective with greater force and greater penetration. A dive bomber, at its point of bomb release, is slowed down by the action of its wing flaps; a fighter bomber in its shallow dive is traveling under its full engine speed.

The fighter-bomber is well suited to carry the rocket bombs now reported as progressing beyond the experimental stage. When a rocket bomb is released, a rocket charge in its tail is set off. This extra kick would provide the missile with the penetration of a heavy bomb dropped from a high altitude.



DURING APPROACHING POWER DIVE, PILOT STRAFES TARGET WITH BURSTS FROM WING GUNS

WHY THE FIGHTER

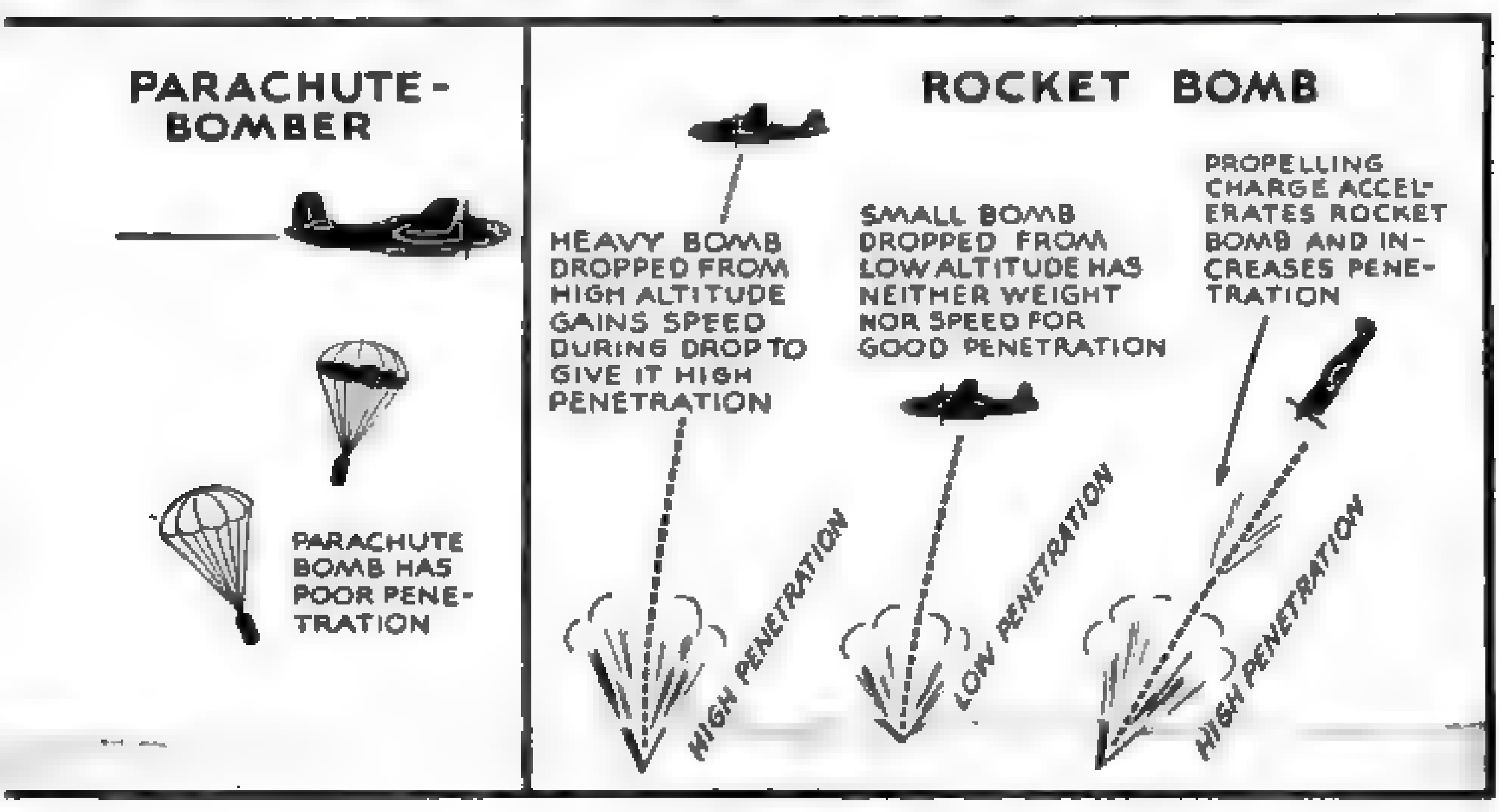


ATTACKERS

SPEED AND MANEUVERABILITY OF WARHAWK (P-40F) MAKE IT A GOOD FIGHTER-BOMBER. THE INSTANT BOMB IS RELEASED, IT CAN CLIMB TO ENGAGE ENEMY FIGHTERS

When a Fighter-Bomber Releases Its 500-Pound Delayed-Action Bomb at the End of Its Power Dive, the Bomb Drops with the Speed of the Plane, Which May Be More Than 500 m.p.h. This Gives Good Penetration

MAKES A GOOD BOMBER



Here is the "famous" German 88 dual-purpose high-velocity gun. Some writers have spread a false impression that the Nazis stole a march on the United States in the development of high-velocity cannon. Nothing could be farther from the truth. Our troops have not been outsmarted by the 88 or any other Axis weapon.

American Guns Do Not Lack Punch, They Are—

TANK KILLERS WITH A WALLOP

By ARTHUR GRAHAME

AMERICAN troops, moving into action on battlefronts all over the world, are tackling our enemies with some of the world's best-designed, best-made weapons, and those weapons include many types of high-velocity guns.

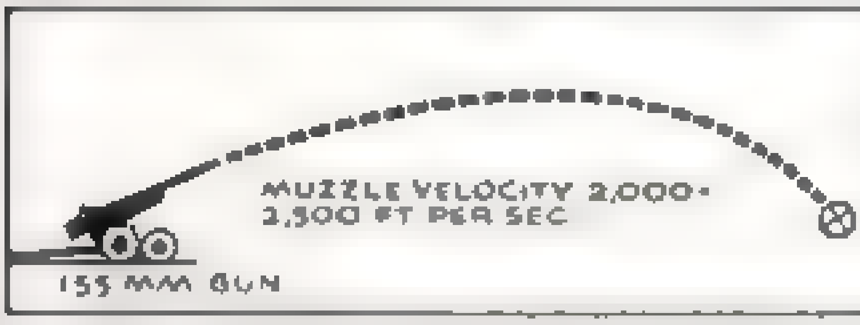
High velocity already has played an important part in the war, and is sure to be an even greater factor in the battles to come. In land fighting, the tank and the airplane carry the main offensive punch; experience has shown that they must be countered by better tanks and better planes, supplemented by the destructive fire of high-velocity guns, blasting out their shells at terrific speeds ranging up to 3,000 feet a second.

The principles of high-velocity shellfire are commonplace to military technicians, but average men and women knew nothing of the subject until they began reading and hearing about the German 88-mm. gun—a useful but totally unmysterious weapon which received almost fantastic publicity in the American and British press during the summer fighting in Libya and Egypt.

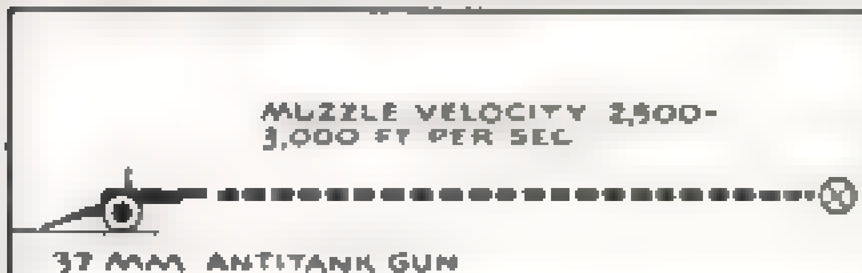
German 88's were used with deadly effect in a spectacular desert ambush that knocked out 230 of 300 British tanks. Overnight the 88 became the most talked-of gun in the war. Tall tales of its power got into print, magnifying it to the stature of a full-fledged

WHAT MAKES A GUN A HIGH-VELOCITY GUN?

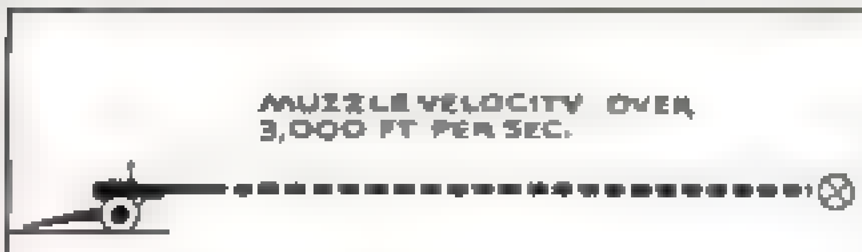
LOW VELOCITY. Guns with muzzle velocities under 2,000 feet a second. Most howitzers are in this class. Because of the relatively low velocity, the projectiles must be fired in a high trajectory to reach their target



MEDIUM VELOCITY. Guns with muzzle velocities of between 2,000 and 2,500 feet a second. Our 155-mm. gun and our modern 75-mm. gun are in this class, together with the Japanese 75-mm. and the Russian 76-mm. field guns



HIGH VELOCITY. Guns with muzzle velocities of between 2,500 and 3,000 feet a second. Included in this class are nearly all naval guns, antiaircraft guns, antitank guns, tank guns, and our 16-in. seacoast defense guns



HYPER-VELOCITY. Guns with muzzle velocities of more than 3,000 feet a second. Not many of this class are in use now, but such guns will be the top antitank and antiaircraft guns of the not-too-distant future

"secret weapon." Writers with more imagination than information noticed the long barrel shown in pictures of the gun and jumped to the conclusion that it was a semi-rocket gun, a mere projecting tube to fire a rocket-shell which kept gaining terrific velocity in flight by means of successive propelling explosions in a combustion chamber in its base.

These fanciful stories did serve a useful purpose by interesting the public in high-velocity guns. Unfortunately they also gave many people the discouraging impression that the Nazis had developed a new weapon which we couldn't match. The fact is that we have high-velocity guns as good as or better than the corresponding German models, and we're going to have a lot more of them before we're through.

The only new thing about the German 88 was the way it was used by Field Marshal Rommel's antitank expert, General Walter Nehring. Actually high-velocity 88-mm. field guns were used by the Germans in the first World War; they were among the types called "whiz-bangs" because of the speed with which the shell zipped through the air and burst.

The present 88, firing its shells at about 2,800 feet a second, is a Krupp-built descendant of the Swedish Bofors 88-mm. antiaircraft gun which the Nazis tested thoroughly during their "rehearsal" war in Spain. It is a good antiaircraft gun, but not the best. Our 3-inch AA gun; almost a half inch smaller, has at least as high velocity; our new 90-mm. gun, and the British 3.7-inch AA guns likewise are equal.

What the Germans did do was to get the jump on the British, converting their AA gun into an all-purpose weapon, equally useful as a tank killer, by mounting it either on tracks or on a field-gun carriage towed by a tractor.

Both the U. S. and British armies are busy with similar conversion jobs. Even more important, the Ordnance Department of our Army has standardized a light antitank gun of super power, about which little information is available except the statement that it can knock out any known tank at extreme range—which clearly means that it has very high velocity.

Another new U. S. model is the 4.5-inch corps-artillery gun. Several months ago a picture of it was released with a brief statement that in addition to its value as a support gun it would be a potent weapon for antitank work. Since then, questions about it have been discouraged.

In wartime no army or navy gives out detailed information about its new weapons until it is certain that the enemy has learned all there is to know about them, but General Campbell, our Chief of Ordnance, says that several of our field and antitank guns have outmatched the German 88, and that we have dual-purpose guns with higher velocity and heavier hitting power than the Nazi ace gun.

In talking about high-velocity guns it helps to define just what is meant by high velocity. No projectile propelled by exploding gunpowder can accurately be called slow—even the bullet from the familiar little .22 short cartridge travels almost as fast as sound. There are no hard-and-fast dividing lines, but for convenience guns may be divided into these velocity classes:

LOW VELOCITY. Guns with muzzle velocities of under 2,000 feet a second. Nearly all howitzers are in this class, as are the older models of 75-millimeter and other field guns of about 3-inch caliber.

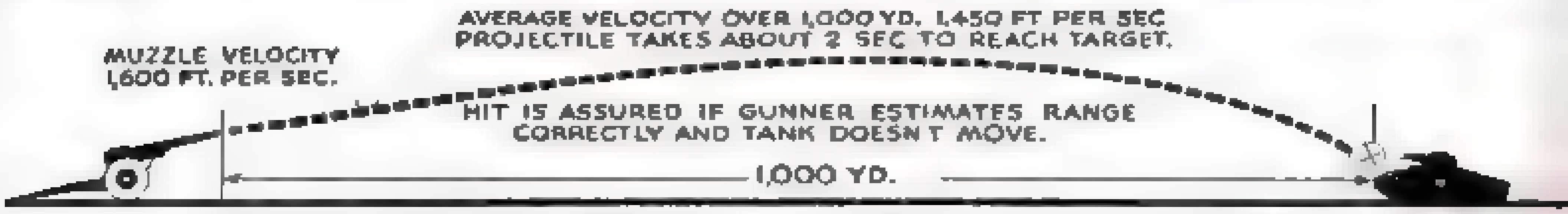
MEDIUM VELOCITY. Guns with muzzle velocities of between 2,000 and 2,500 feet a second. Our 155-millimeter gun, the Japanese 105-millimeter howitzer, and the more recent models of American and Japanese 75-millimeter and Russian 76-millimeter field guns are in this class.

HIGH VELOCITY. Guns with muzzle velocities of between 2,500 and 3,000 feet a second. Included are nearly all naval guns; nearly all antiaircraft guns, both land and naval; various American, British, Russian, German, and Japanese antitank guns of from 37 to 57-millimeter (about 1½ to 2¼-inch) caliber; most tank and tank-chaser guns; our 16-inch seacoast defense gun; and—probably—the British 25-pounder (about 4¼-inch) gun howitzer when it is fired with a supercharge propelling an armor-piercing projectile. Almost certainly in this class is the Russian 12½-foot-barrel, 76.2-millimeter (3-inch) "Putilov" light field gun—such bad medicine for tanks that the Germans sent some of those they captured to Rommel.

HYPER-VELOCITY. Guns with muzzle velocities of over 3,000 feet a second. Not many are in use now, but they probably will be the top antitank and antiaircraft guns of the not-distant future.

The fact that a gun isn't in the high-velocity class doesn't mean that it isn't a good gun, or that it is obsolescent. For use against stationary, unarmored, and usually unseen-by-the-gunner targets, howitzers—most of which have muzzle velocities of about 1,500 feet a second—are invaluable weapons. Their advantages over high-velocity guns are that they can lob shells over hills to blast gun emplacements, ammunition dumps, and fortifications which are protected by the lay of the land from successful attack by flat-trajectory guns, that in proportion to their size they can fire heavier projectiles, that they are easier to

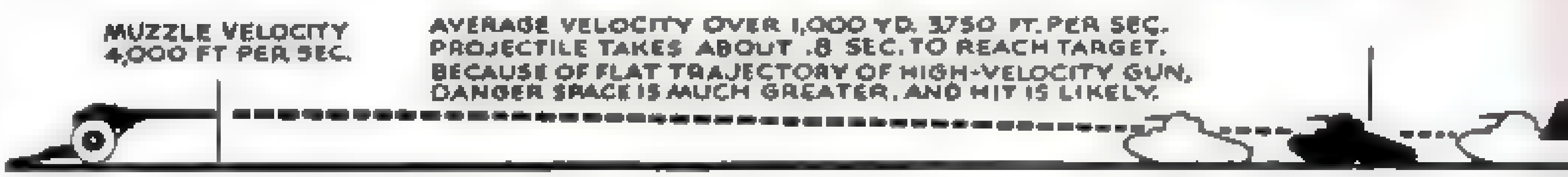
WHY HIGH-VELOCITY GUNS ARE NECESSARY IN FIGHTING TANKS



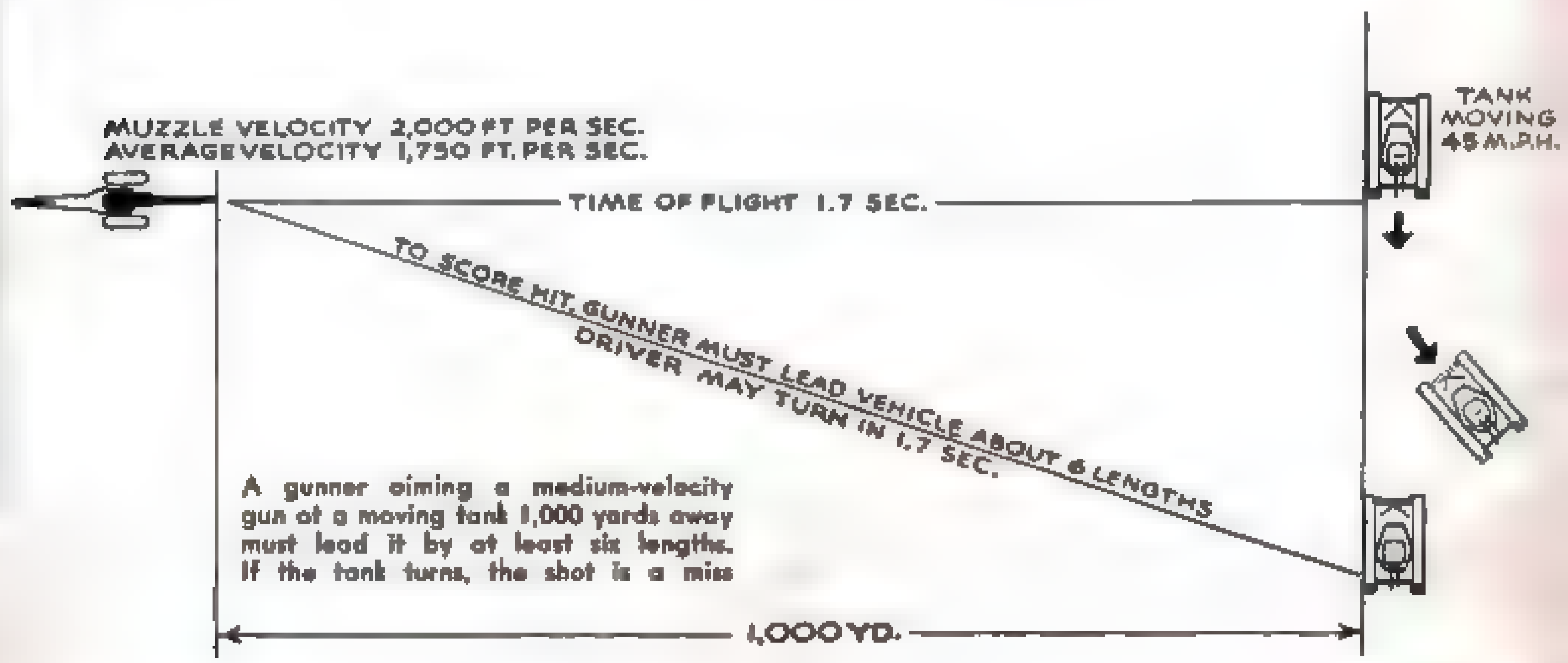
A projectile fired from a low-velocity gun at a tank 1,000 yards away takes two seconds to reach its target. If the tank is standing still and the aim is accurate the gunner can score a hit . . .

. . . but if the tank moves either forward or back the shell will miss in spite of the accuracy of the aim. A tank traveling 25 miles an hour will move more than 12 yards in the two seconds

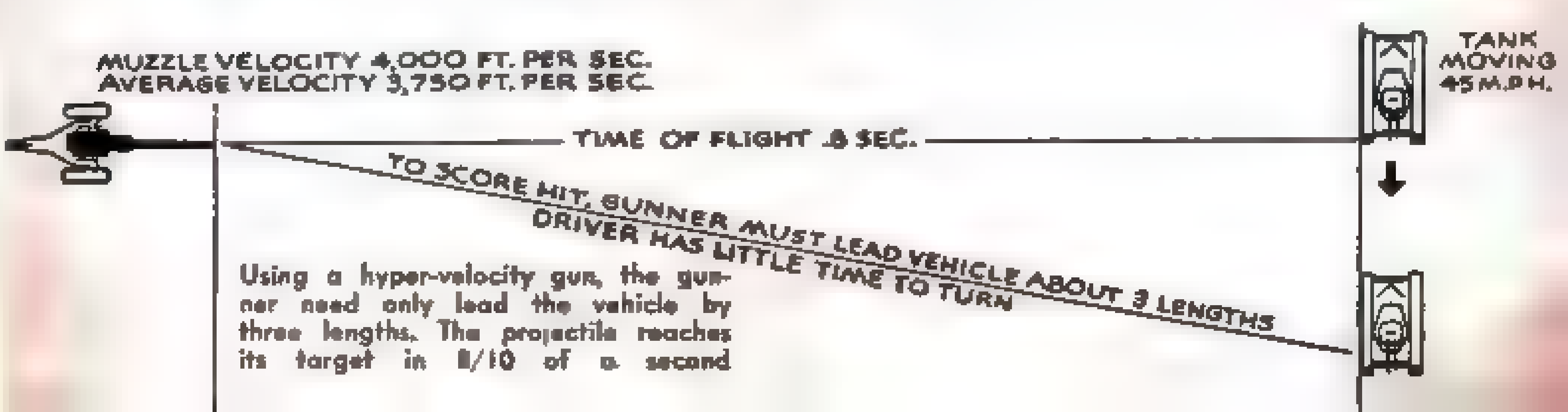
With a low-velocity gun, accurate aim is difficult when every shot must count and direct hits are necessary. The slightest error in elevation will place a shell yards from the target



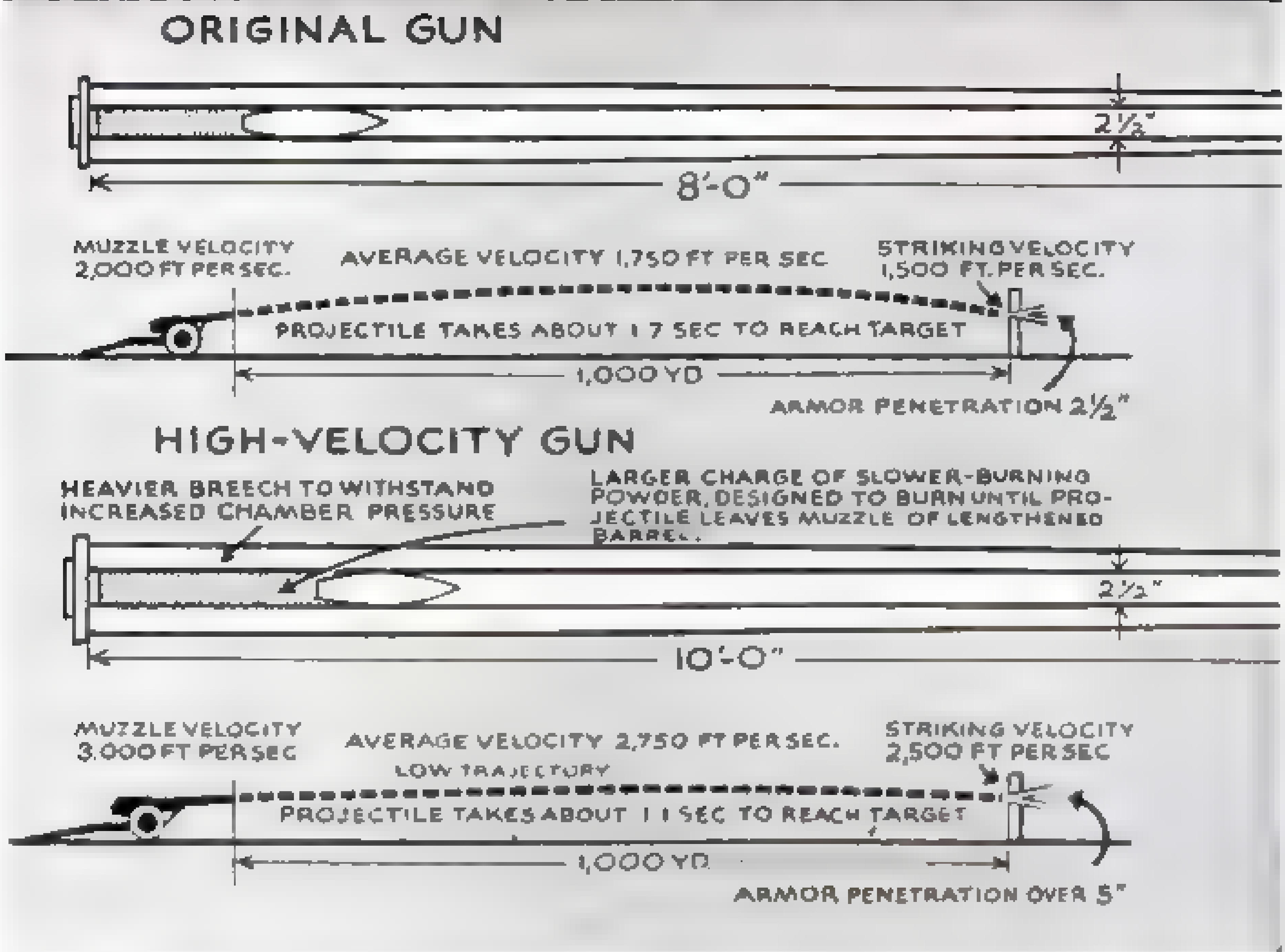
Because of its flat trajectory, a shell fired from a hyper-velocity gun not only reaches the target faster but eliminates misses caused by forward or backward movement of the target



A gunner aiming a medium-velocity gun at a moving tank 1,000 yards away must lead it by at least six lengths. If the tank turns, the shot is a miss



Using a hyper-velocity gun, the gunner need only lead the vehicle by three lengths. The projectile reaches its target in 8/10 of a second



The entirely supposititious example above shows how ordnance experts go about increasing the velocity of a gun. Originally the 2½-in. gun had a muzzle velocity of 2,000 feet a second and an armor penetration of 2½ in. at 1,000 yards. Redesigning boosted velocity to 3,000, penetration to 5 in.

protect from enemy artillery, and that because their rifling doesn't wear out nearly so quickly they can be used almost continuously for harassing fire.

The advantages of high-velocity guns over low-velocity howitzers and medium-velocity guns is that they get their projectiles to moving targets much faster, and that against armored targets such as ships and tanks the higher striking velocity of their projectiles gives them much greater penetration.

With the appearance of the armored warship almost 90 years ago the designers of naval guns started trying to obtain higher velocities to penetrate the ironclad's defenses. Improvements in powder and in steel-making processes resulted in the development of larger guns of greater penetration, but the improvements in steel making also resulted in the production of heavier and tougher armor plate. As a consequence of this long race between offense and defense practically all naval guns are in the high-velocity class.

In land warfare, in which targets nearly always were stationary or slow moving and seldom were armored high-velocity guns did not become necessary until the advent of the airplane in World War I. Then they were improvised hurriedly. Our antiaircraft gun was as good as any of them; it was essentially a 75-millimeter field gun mounted muzzle up, and it had a muzzle velocity of about 2,000 feet a second and a vertical range of about 30,000 feet. Shortly after the war our Army gun designers developed and improved that improvised weapon into our 3-inch antiaircraft gun, which has a muzzle velocity of at least 2,800 feet a second. Although they are outperformed by our newer 90 and 105-millimeter models these 3-inch guns are more effective than the German 88-millimeter, and some of them have been converted for antitank work.

A gun is very much like an automobile engine. Its barrel is comparable to the cylinder, its breech mechanism to the cylinder head and spark plug, its propellant powder to the charge of fuel vapor, and its projectile to the piston which is driven down the cylinder bore by the expanding gases resulting from the explosion in the cylinder chamber.

A gun must be designed around the powder which is to be used in it. The first requisite is that its breech be strong enough

...OTHER GUN?

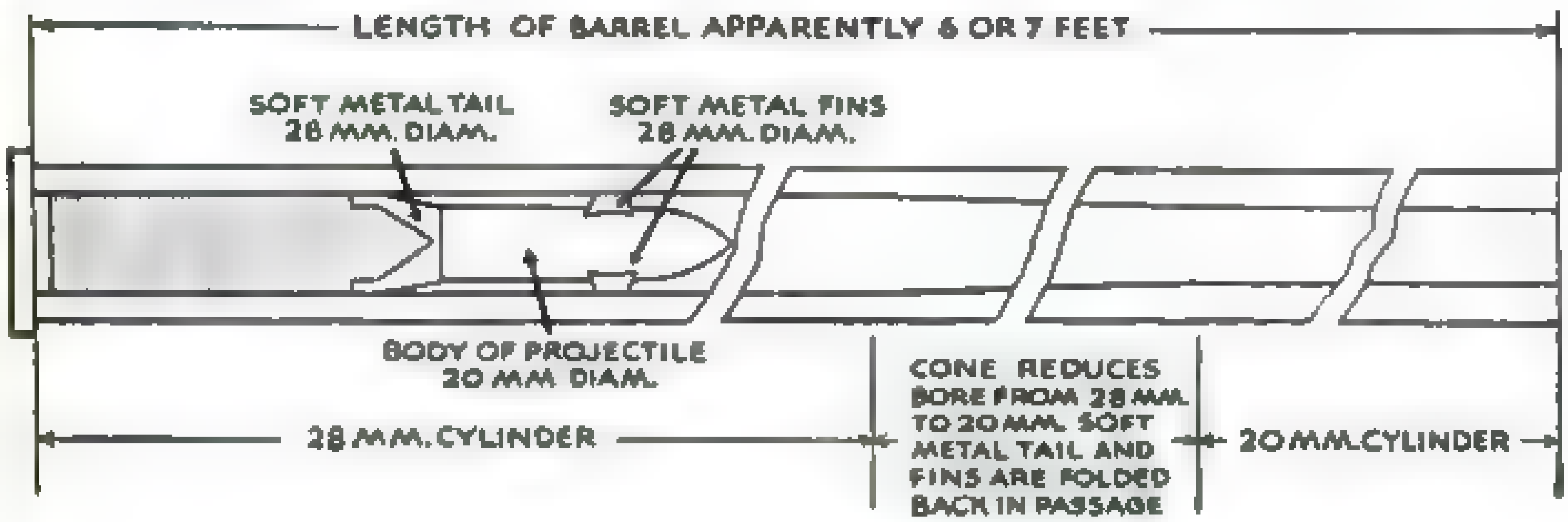
Our M-4 medium tanks are now coming off the lines with high-velocity cannon mounted in their turrets. Compare the length of the gun above with the low-velocity gun below, also mounted in an M-4 tank turret

In their Mark IV tank, shown below, the Germans mount an 88-mm. gun-howitzer. In combat, however, the U. S. Army's high-velocity 3-in. tank gun has more than outmatched them. High velocity and high penetration make our guns good tank killers

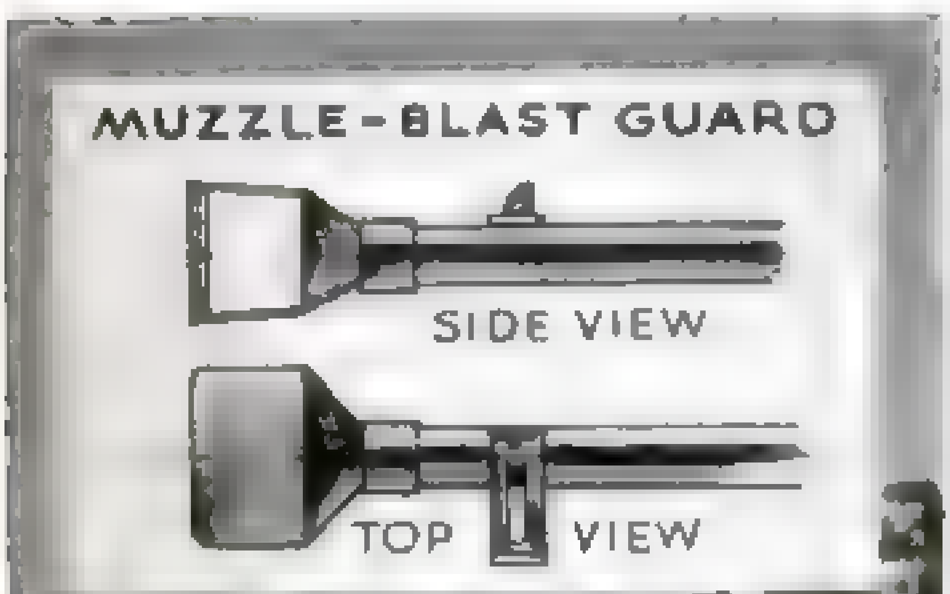
How our 75-mm. and 90-mm. shells compare with the much-talked-about German 88-mm. shell for antitank fire

This small-caliber German antitank gun, which has been referred to as the Gerlich gun, is probably a development of the Halger-Ultra military rifle invented by H. Gerlich, an American, in the early 1930's

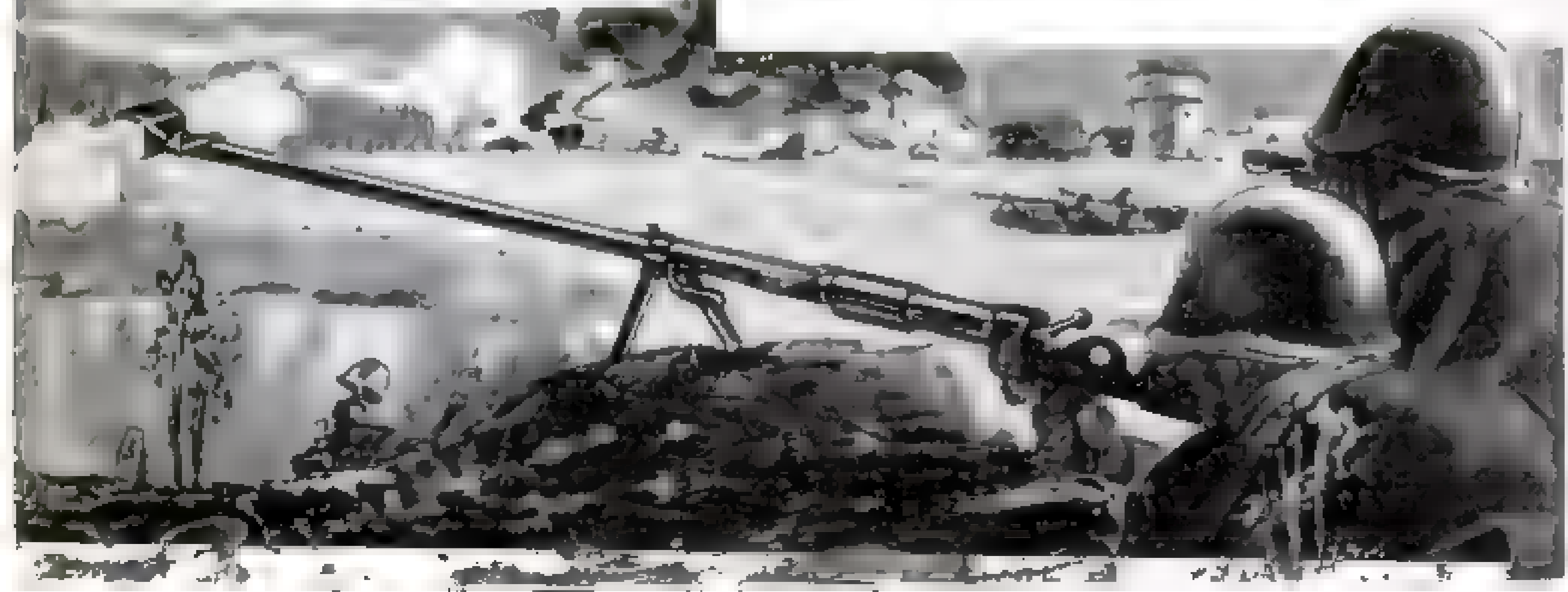
TAPERED BORE GIVES THIS GERMAN GUN ITS HIGH VELOCITY



How the German Gerlich gun works. Like Gerlich's Halger-Ultra rifle, it has a reduction cone that squeezes the 28-mm. soft metal fins down on the 20-mm. steel slug as the projectile passes through. This squeezing effect, which produces a very high muzzle velocity, gave it the nickname "squeeze gun"



RUSSIAN ANTITANK RIFLES are single-shot .57 caliber high-velocity guns. They have high penetration against light tank armor and are carried and manned by two men. Because both the Russian rifle and the German gun above are fired close to the ground they are fitted with blast guards which force the gases out sideways at the muzzle and prevent them from kicking up clouds of dust and obscuring the gunner's aim

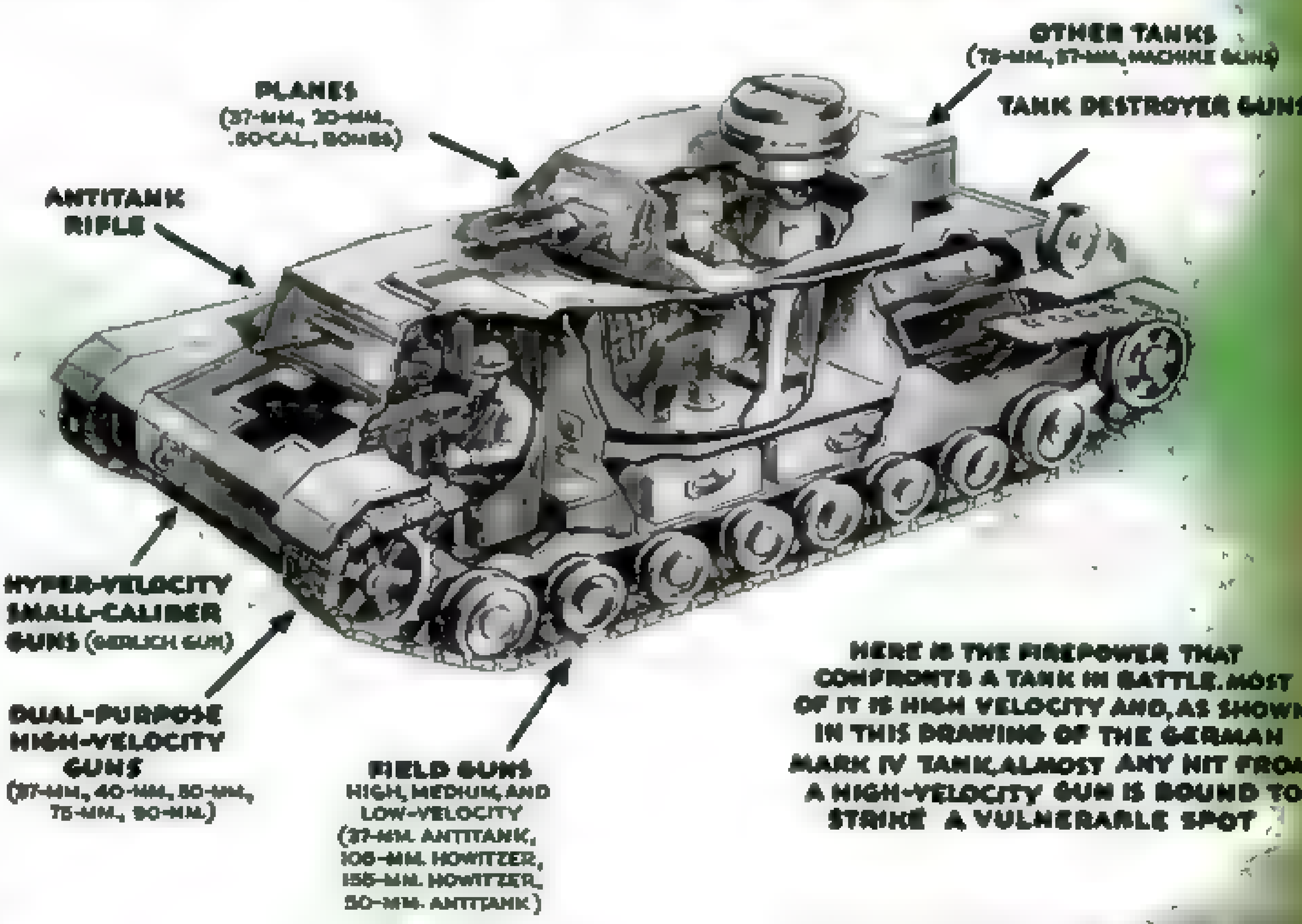


to withstand the pressure set up by the explosion in the powder chamber. A long barrel is the distinguishing mark of a high-velocity gun. High muzzle velocity is obtained by using nitrocellulose powder made in multiperforated cylindrical grains which burn progressively and comparatively slowly both from outside in and inside out, and gradually build up increasing pressure back of the projectile until it is driven out of the barrel. A long barrel is necessary because a short one wouldn't give the slow-burning propelling charge enough time to exert its maximum pressure behind the projectile. The practical limit of barrel length is about 60 times the caliber of the gun—15 feet for a 3-inch gun. If the barrel is longer than that, the increased friction caused by the passage of the projectile through the longer rifled bore neutralizes the advantage of continued gas pressure, and "whip" is likely to develop in the over-long barrel and ruin accuracy. High-velocity guns are rifled in the same manner as low or medium-velocity guns of the same caliber. But their barrels wear out sooner; they are good for only 5,000 or 6,000 rounds.

The instant a projectile leaves the gun barrel it begins to lose velocity. The shape of a projectile plays a highly-important part in its retaining velocity in flight. Boat-tailed projectiles cleave the air much better than flat-based ones, so most projectiles used in high-velocity guns are boat-tailed.

The greatest advantage of high velocity in an antiaircraft gun is that it reduces the projectile's time of flight from the gun to the rapidly moving target. Its greatest advantage in an antitank gun is that it increases striking velocity, and so increases armor penetration. The weight of a projectile also plays an important part in its ability to go through armor. Our 16-inch seacoast defense gun and our .30 caliber Garand rifle have the same muzzle velocity of 2,700 feet a second, but the 16-inch shell will go through armor at 30 miles which the rifle bullet couldn't even dent at 30 yards. But for a projectile of the same weight and shape, increasing striking velocity greatly increases penetration. A one-pound projectile with a striking velocity of 4,000 feet a second (Continued on page 230)

TANKS ARE EASY PREY FOR HIGH-VELOCITY GUNS



HERE IS THE FIREPOWER THAT CONFRONTS A TANK IN BATTLE. MOST OF IT IS HIGH VELOCITY AND, AS SHOWN IN THIS DRAWING OF THE GERMAN MARK IV TANK, ALMOST ANY HIT FROM A HIGH-VELOCITY GUN IS BOUND TO STRIKE A VULNERABLE SPOT

What About Car Rubber?

EXCLUSIVE OF TIRES, THE AVERAGE CAR HAS NEARLY 40 POUNDS OF IT IN 300 PLACES. IT NEEDS CARE, TOO

By SCHUYLER VAN DUYNE

ANYBODY is lucky today if he has five tires on his car. He is lucky even if he has four. He should be equally thankful for the nearly 300 other rubber parts on his car, each performing an important service. They make up a volume and weight almost equal to two automobile tires, but because they rarely get talked and written about, they are generally neglected.

Consulting competent rubber experts, POPULAR SCIENCE has gathered information to guide motorists in the care of these important rubber car parts. While they vary widely in rubber content and some are of

Oil swells rubber, which bursts the woven jacket of ignition cable. Remove oil with naphtha then brush on a good-grade insulation varnish

Heater hose must not touch hot manifolds nor rub against engine parts. Sturdy brackets should be mounted to keep it clear, as in photograph above

synthetic rubber, the life of any of them can be extended by proper attention.

It is of first importance to know that the unremitting enemies of all natural rubber and many synthetic varieties are oil, heat, sunlight, oxygen (particularly the ozone in air), and abrasion. Rubber care therefore means fighting back at these enemies, and the line of attack to follow is summarized below under separate headings into which most of the parts fall.

Radiator hose. Wipe the outsides occasionally with a rag soaked in naphtha, in the open air so that the naphtha will dry quickly and completely. Coat the hoses with any good tire side-wall paint, which commonly is black asphalt-base material that never completely dries. If the hose is old, insert a coil spring of diameter slightly less than the inner diameter of the hose to prevent collapsing. The latter is particularly

At left, a wire coil in radiator hose prevents collapse from suction as closed cooling systems cool, or during operation in lower hose of normal systems

AUTOS

important in closed cooling systems and in the intake (lower) hoses of all systems. Do not use grease to seal hose connections, nor let your engine boil over. Never tighten hose clamps so that they cut into the rubber.

Heater hose. The same general care is required as for the radiator hose. Always be sure, however, that the hose is tied or bracketed away from the engine and manifolds, and that it does not rub against any under-hood parts. Wrap it with asbestos if it cannot be moved well away from the exhaust manifold. Have the hose pressure-cleaned with each radiator cleaning. If possible, remove it completely in summer and store it in a cool, dark, dry place. And remember that a piece of garden hose makes excellent heater hose.

Fan belt. Keep it freed of grease and oil by an occasional naphtha cleaning. Adjust it frequently, by moving the generator, to the tension recommended by your car's manufacturer—usually a maximum in-and-out play of 1½ inches. This prevents slipping, which generates heat of friction and speeds wear. Check the pulley alignment, too. A good belt dressing made for the purpose may be applied.

Ignition cable. Failure here usually occurs when oil and grease swell the rubber and break the woven jacket, permitting high-voltage-current leaks. Clean the wires

8. The same applies to rubber mats in car trunks

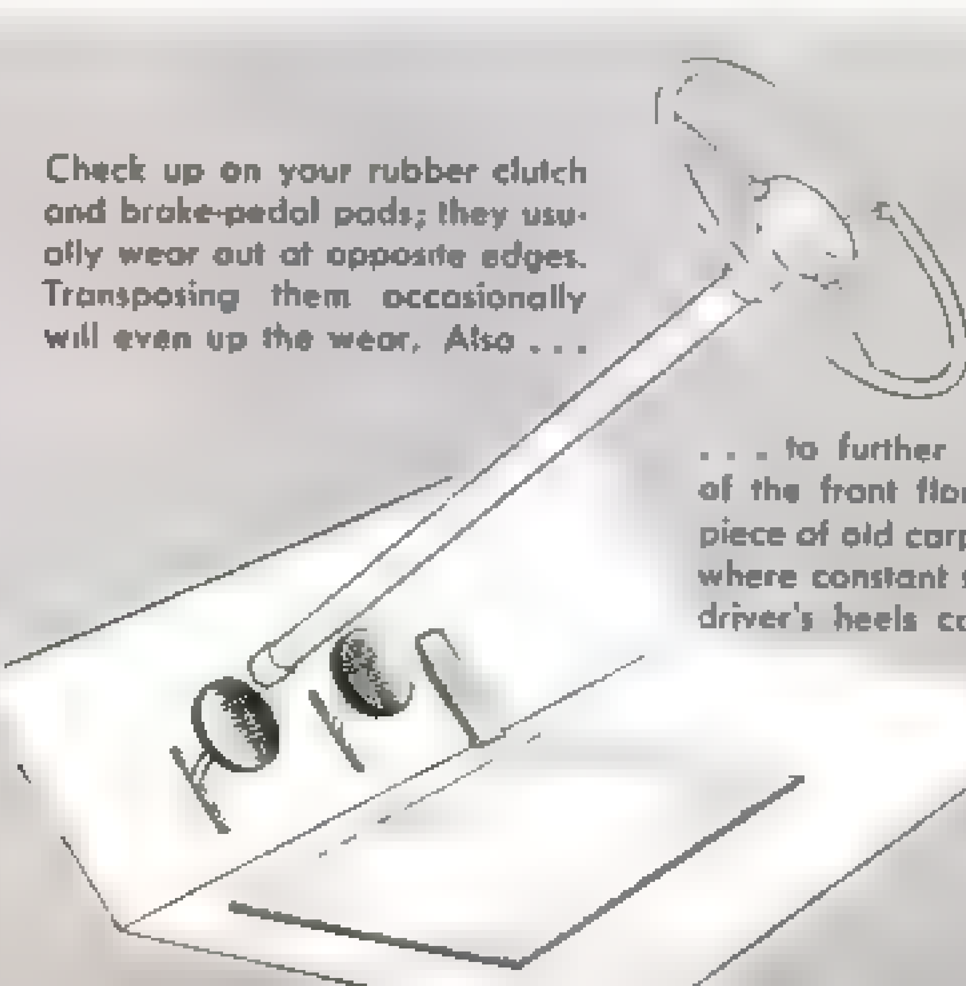
occasionally with naphtha, in the open. Wipe off the dust now and then between cleanings. Prevent all wires from contacting hot spots on the engine, and also from rubbing against car parts and each other. A coating of top-grade electrical-insulation varnish is recommended.

Floor mats. These generally are made of reclaimed rubber, with rather low resistance to tearing but adequate resistance to wear, provided they are kept clean. First, be sure that they lie flat (both in the driver's compartment and in the trunk compartment). If the insulation or padding underneath the front mat is creased or torn, pad it out with newspapers so the mat will lie smooth. Second, keep the mat well brushed at all times, or pebbles brought in on the feet will soon scuff it and wear it away. Third, it is advisable to place a piece of carpet over the area beneath the driver's feet, close to the brake, clutch, and accelerator pedals, where serious wear shows up first. Finally, apply any good liquid floor or car-body wax.

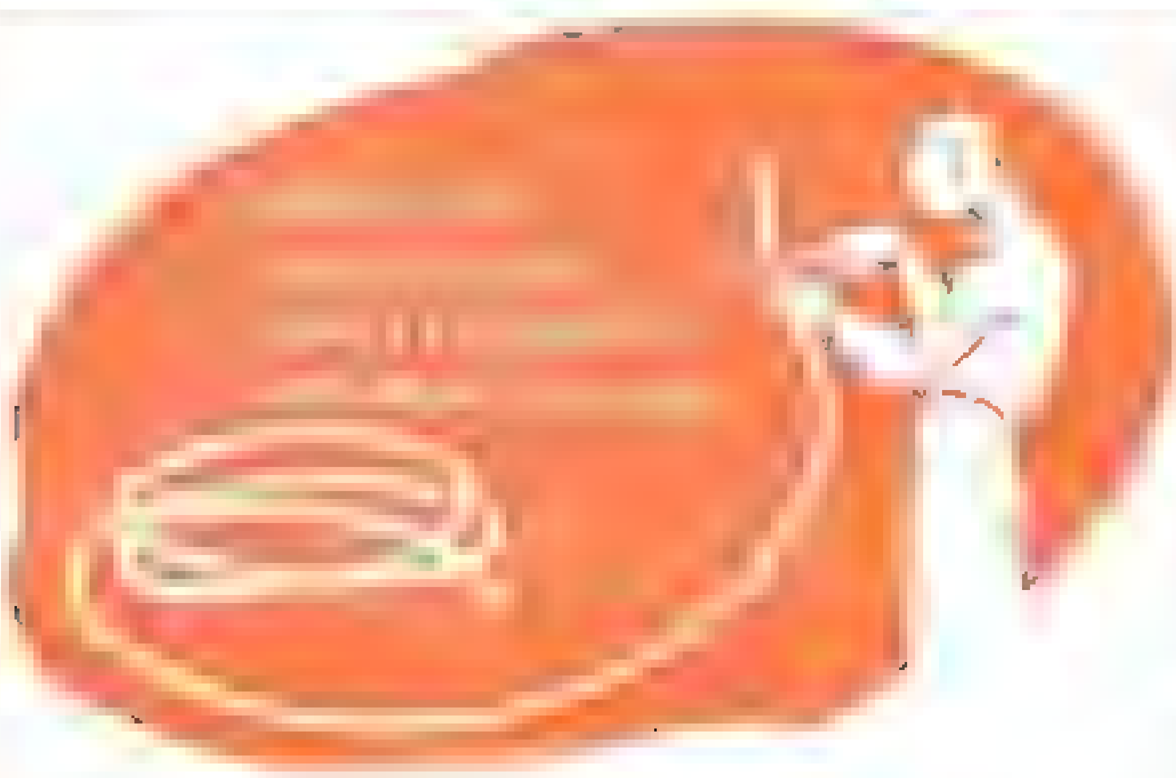
Sponge rubber. Its most common car use is for door weatherstripping which, while spongy inside, is usually smooth-surfaced. Therefore, either coat it with a good grade of flexible varnish, giving it plenty of time to dry before closing the doors again, or ap-

Fan-belt tips: Clean off oil and grease with naphtha; apply good belt dressing to back now and then; check up on belt tension. Slipping belts wear out rapidly

Check up on your rubber clutch and brake-pedal pads; they usually wear out at opposite edges. Transposing them occasionally will even up the wear. Also . . .



. . . to further increase the life of the front floor mat, fasten a piece of old carpet over the area where constant scuffing from the driver's heels causes most wear



Garden-type hose is good for heaters, but be sure you have a new connector before cutting the old one from a good hose

ply liquid polishing wax. There is nothing you can do to preserve sponge-rubber seat cushions unless you remove the upholstery. Authorities declare, however, that the cushions normally will outlast the car, so the only thing to remember is not to clean the fabric upholstery with anything that dissolves rubber.

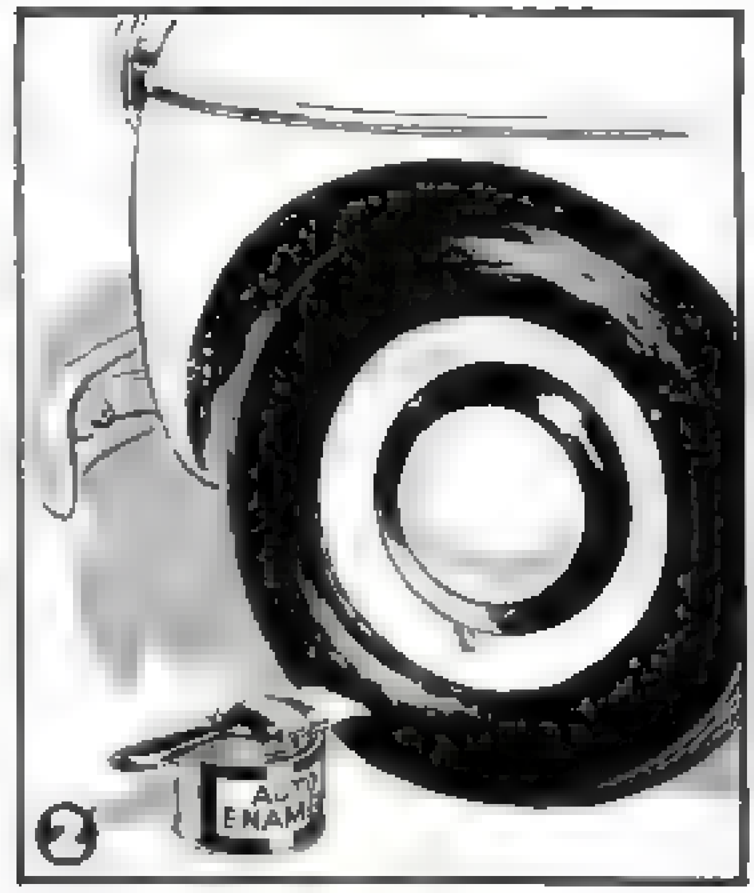
Grommets. These are found all over the car, at bumpers, license brackets, carrying cables through panels, and so on. Keep them coated with car wax or flexible varnish. When they become separated from body panels, as on bumper supports, clean the surfaces with naphtha, dry, and treat with a resin-plastic adhesive powder of the type that you mix with water. Clamp firmly in place for 12 hours. The same treatment will fasten loosened sponge-rubber door weatherstripping back in place.

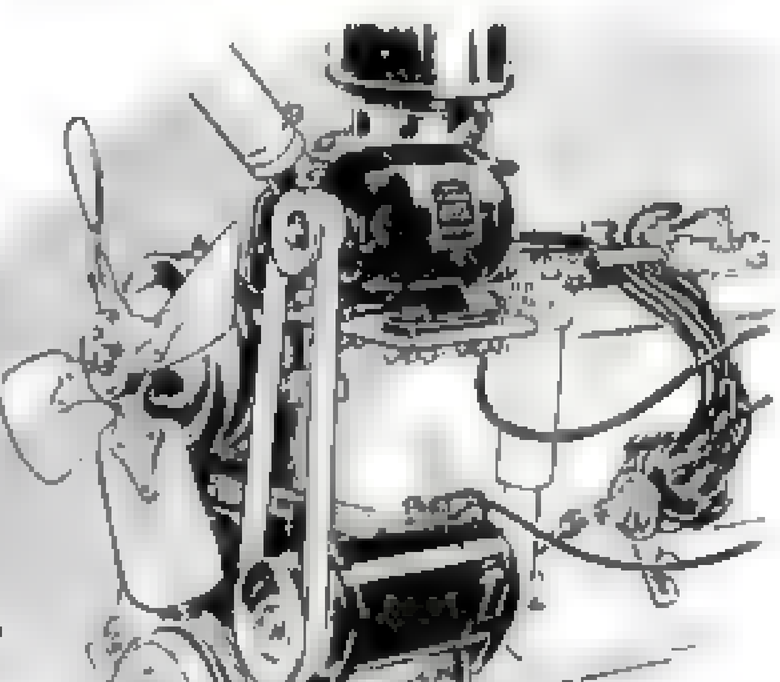
Window channels. Pry the outside lip slightly away from the glass with a putty knife and brush in liquid polishing wax. Then rub the wax on the weather-exposed surfaces of the channels.

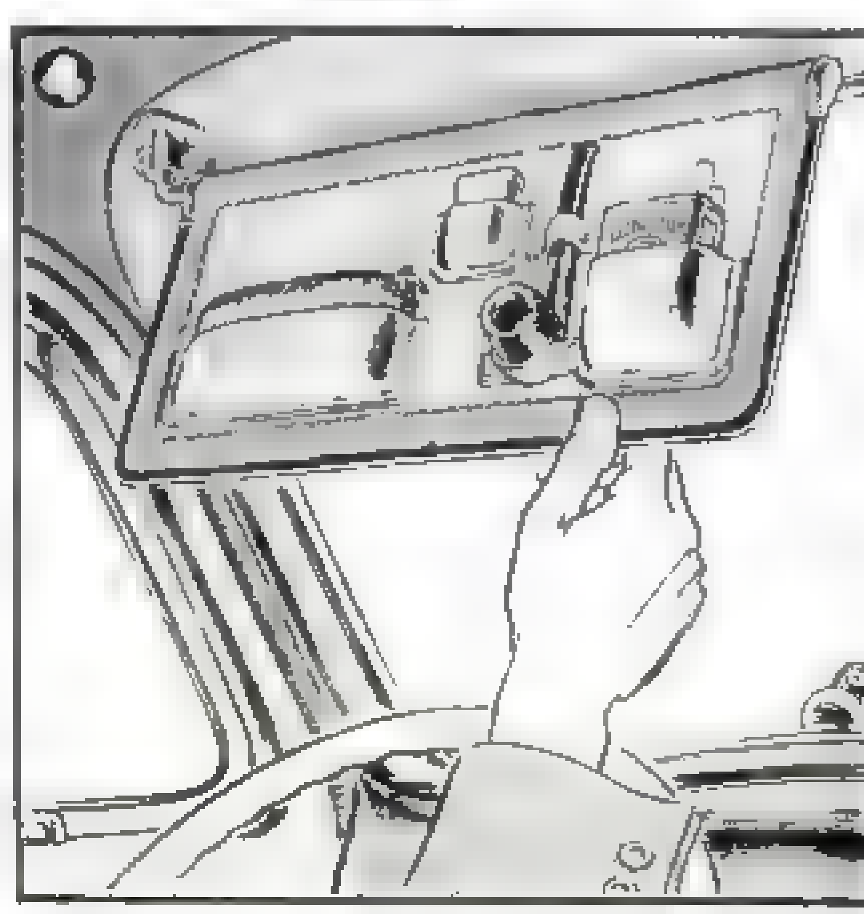
For its effect on radiator and heater hose and, on some cars, synthetic-rubber water-pump packing glands, the car owner should weigh carefully the importance of using good antifreeze in his car cooling system. A makeshift antifreeze may save a few cents for a while, but later require not only an expensive engine job but new rubber fittings that may well be unobtainable.

There are other rubber parts, too numerous to detail, and varying from car to car, which you will find if you look for them under and inside your car. Cleanliness will add to their life expectancy, and wax or flexible varnish will usually supply a useful protective coating. If you neglect them, don't kick if you cannot buy new ones some months from now.

HANDY AIDS FOR THE







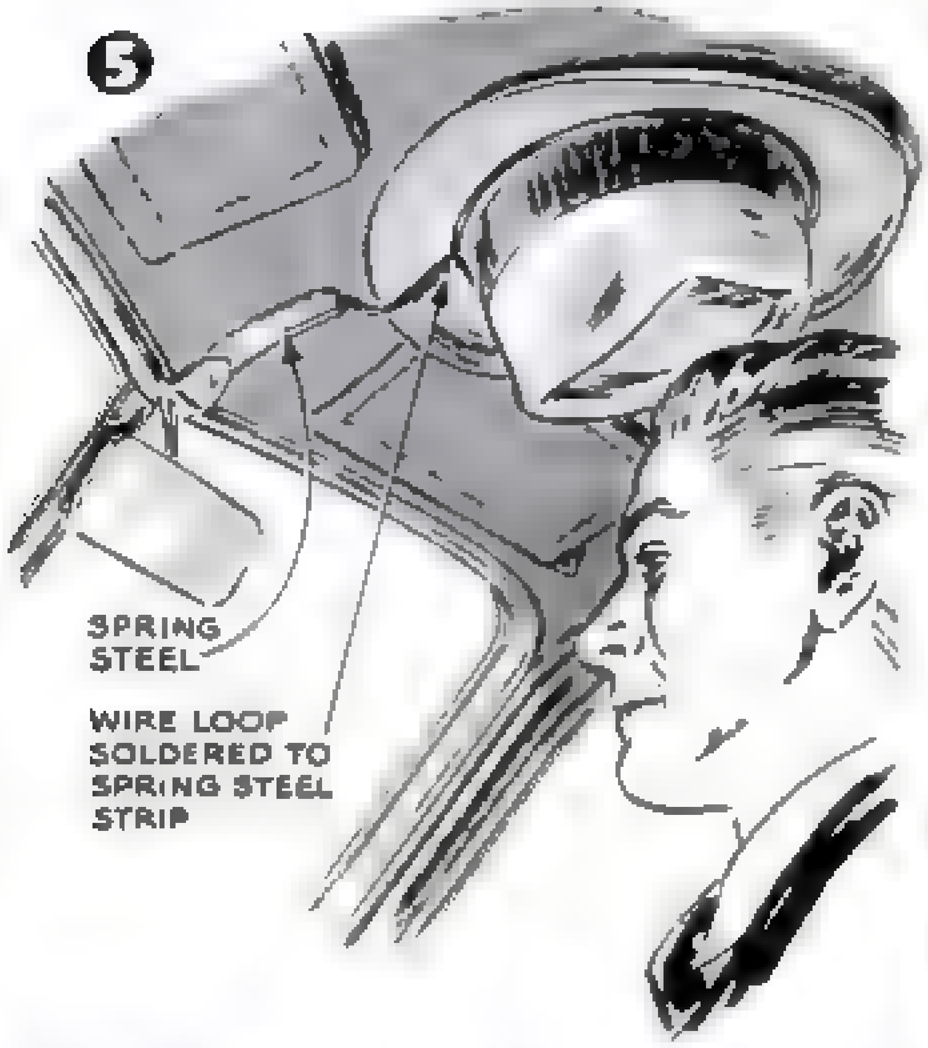
1 DEFROSTER FANS, which frequently are furnished new with plain on-off-type switches, can be made more flexible by replacing the original switch with a rheostat type such as most heater blowers have. The rheostat switch, available at most automobile-accessory stores, costs but a few cents and attaches easily under the dash.—P.V.

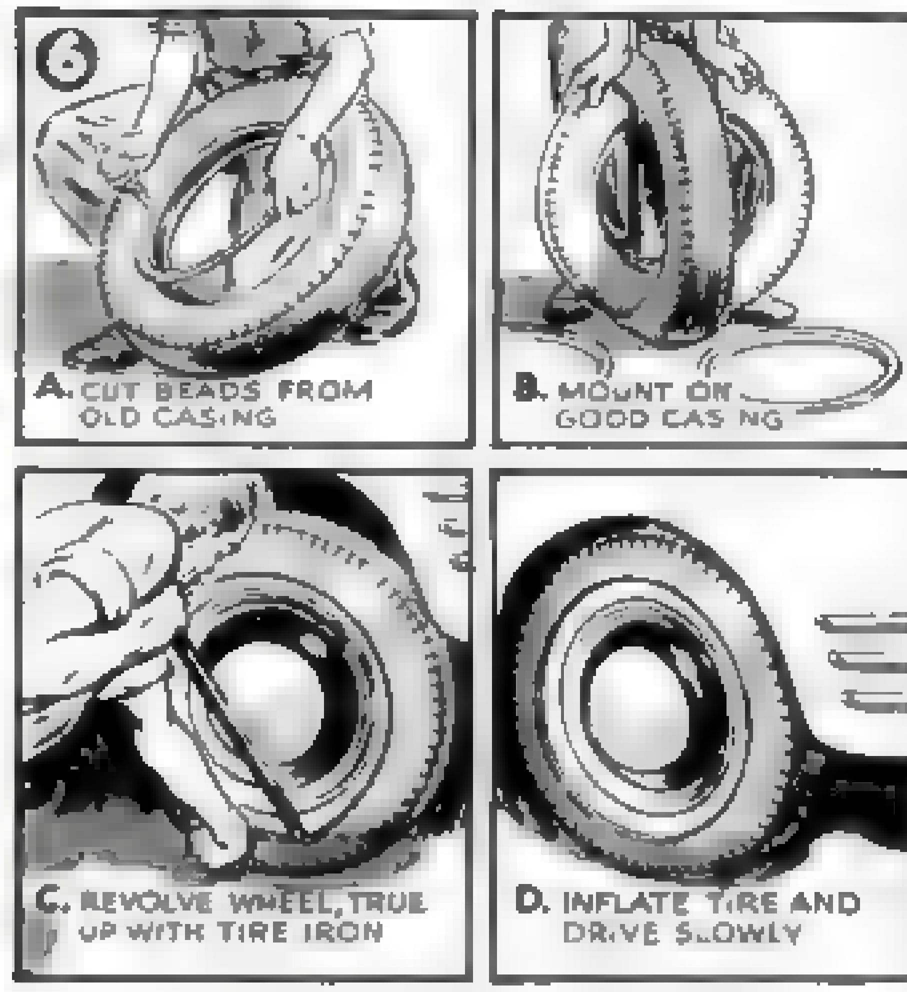
2 WHEEL APPEARANCE is improved by the simple expedient of applying white enamel to the wheel rims, as shown in the accompanying drawing. The resulting effect to the eye is that the car is equipped with white-wall tires. The area covered should extend only from the lip of the rim to the point where the drop-center rim is fastened to the wheel itself.—A.P.

3 LITTLE-USED BATTERIES can be given an occasional charge with an old quarter-horsepower house-current motor plugged into a garage outlet and rigged on the car motor as shown. The electric-motor bed of iron can be permanently bolted to the car-motor studs, and the demountable motor connected to the generator pulley with a short V belt.—C.R.M.

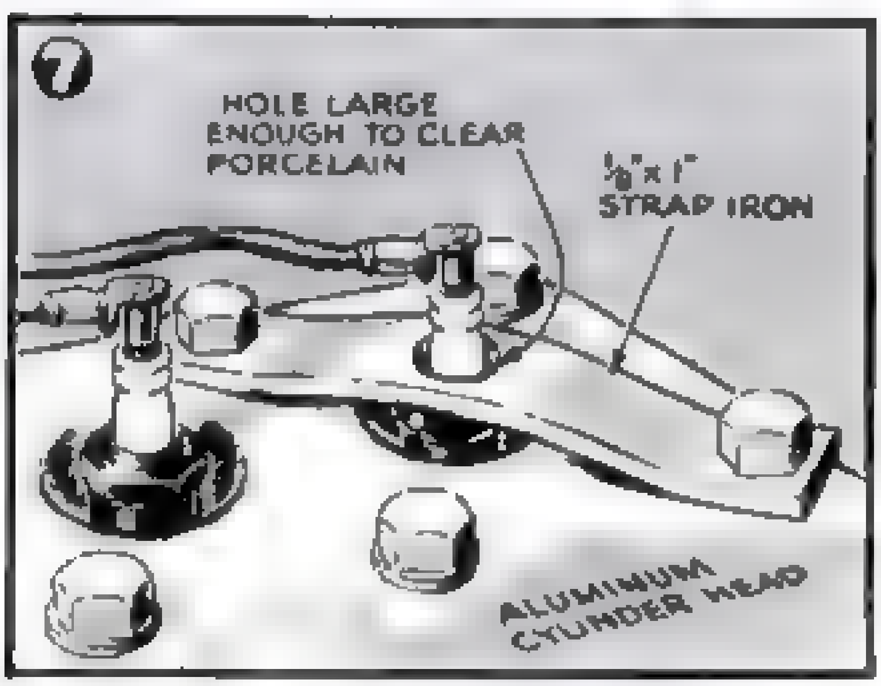
4 A HANDY SMOKER'S SET for the motorist can be made of cut-out pieces of soft leather, sewn as indicated to the top side of one windshield visor. Material from a pair of old kid gloves should furnish all the leather needed.—D.McM.

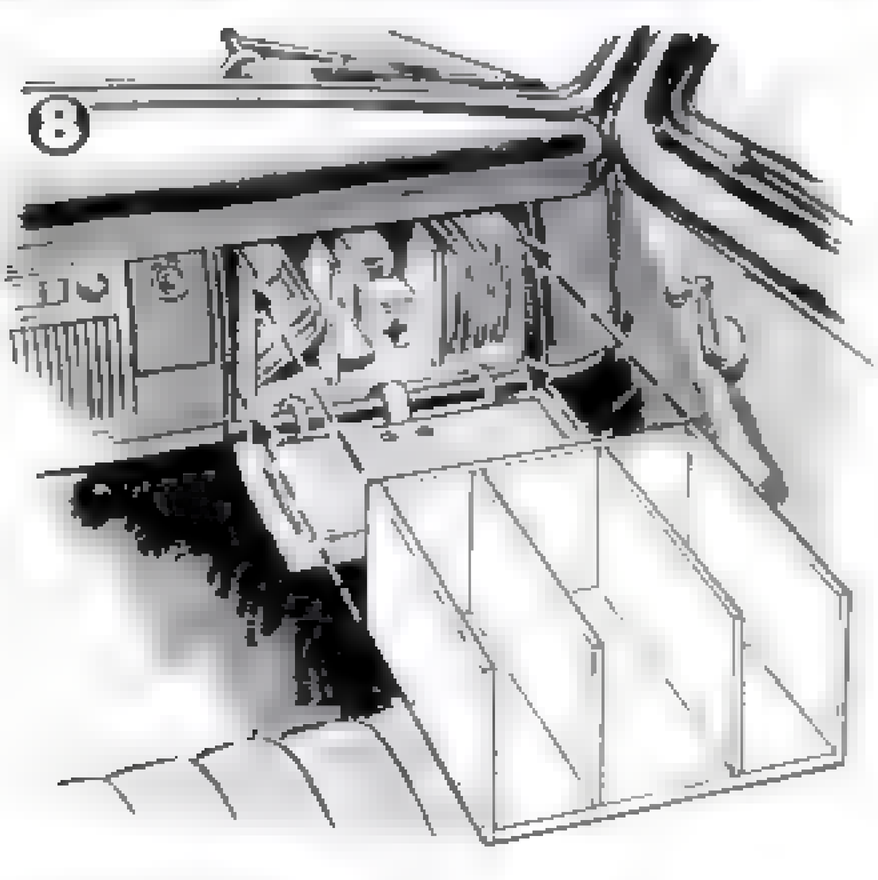
AUTOMOBILE OWNER





DRAWINGS BY STEWART ROUSE



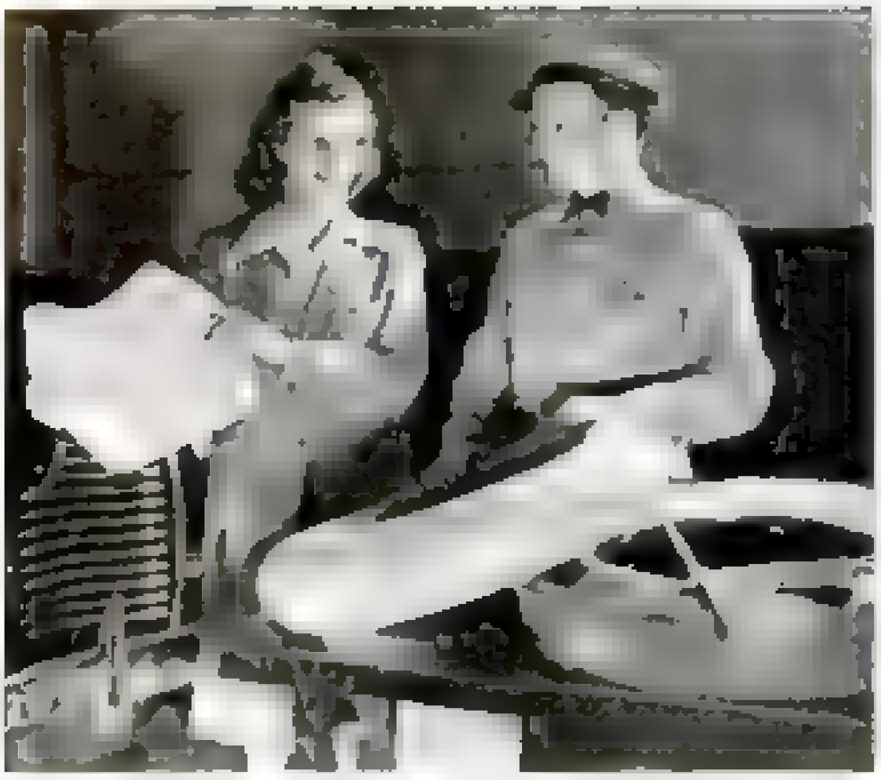


5 A HAT HOLDER that will keep your hat off the car seat and floor while you are driving can be readily rigged up with a wire coat hanger and a strip of steel. Mount the unit as shown in the drawing by making use of one of the screws holding your rear-view mirror in place.—H.N.

6 HOMEMADE TIRE CAPS, good enough for slow, careful driving can be made by the method detailed in the series of drawings above. In cutting off the tire beads to make the cap, cut close to the bead welt. It is absolutely essential to use a tire of the same size as the one over which it is to be mounted.—T.D.

7 BROKEN OR STRIPPED threads in spark-plug holes of aluminum cylinder heads usually call for either a new head, or reboring and rethreading the hole for an oversize plug. a simpler repair is to bolt the plug down with a piece of strap iron, cut and drilled as shown to fit under the heads of two engine studs.—R.H.

8 COMPARTMENTS within your glove compartment will help bring order out of the chaos of articles that usually find their way into this handy catchall. Plywood, cut to your individual requirements and glued or nailed together, is excellent material for the device. Allow for hinge movement, and leave it free for easy removal when desired.—D.McM.



Auto Ideas

INNER-TUBE PROTECTOR. A tire manufacturer, realizing that there may not be any more inner tubes or casings for sale to the general public for the duration, has developed a "girdle" of cotton cord to make tires of prewar vintage last as long as possible. Above, the young woman examines the protector, while the attendant prepares to incase the inner tube. Then, at right, he slips the sheathed tube into a tire that ordinarily would be unfit for use because of body cuts and breaks which would chafe through the tube in a few miles of driving. The protector will be distributed by dealers.

CONCENTRATED CAR WASH. A powder placed on the market in a handy six-wash consumer package makes a bid for popularity as a quick, easy, and all-round car wash. A tablespoonful to a pail of water makes a solution for lifting dirt and grease spots off the metal without the need for following up with a chamois polish. It may be used to clean chromium and windshields. It is also offered for removing spots and shampooing upholstery, seat covers, and fabric tops.

ANTI-CORROSIVE FOR BATTERIES. Fighting corrosion on battery cables is doubly important now, in view of the wartime value of copper. A chemical preparation now on the market is said to completely dissolve and prevent corrosion on terminals, cables, and connections. According to the manufacturers one application, made with a brush as shown in the photograph above, lasts until the battery is removed, as the chemical does not dry out. It is not necessary to remove the cables.

"Or you'll what?" he snarled. "Get inside there, and be sure to keep your hands where I can see them or you'll get hurt!"

GUS never forgets a car

The Way Most of Us Remember Faces, the Model Garage Proprietor Remembers Cars—Once He's Worked on Them

By MARTIN BUNN

IT ALWAYS makes Gus Wilson smile when he hears anyone say that he can't tell his own car from another of the same make and model. Once Gus has worked on a bus he never forgets it. When we ask him how he remembers all of them that come into the Model Garage shop he grins and says: "Oh, I dunno. I just know 'em same as we know people."

Not a very lucid explanation, perhaps, but it's the only one we've been able to pry out of him.

However he does it, Gus's ability to remember cars came in very handy not long ago. Since the war started he has fallen into the habit—his partner Joe Clark calls it a bad habit—of working in his shop almost every evening. One night when he heard a horn honk outside he looked at his watch and saw that it was almost two o'clock. Figuring that he had better call it a day, he began to lock up shop. Then, while he was washing his hands, he was surprised to hear the horn again—he had thought that the would-be customer had driven on. Growling, he unlocked and opened the shop door.

A flashily dressed man was standing there. He was so stout that he was on the verge of being fat; his face, unhealthily gray, had been round but now its heavy cheeks were sagging. A dark-colored coupe, with its engine off and only its parking lights burning, was standing at the gasoline pump.

"You deaf?" the visitor demanded in a greasy sort of whisper. "It took you a plenty-long time to open that door."

Gus didn't like his looks. "We're not open for business," he said curtly. "You'll find an all-night garage down on Main Street, just across from the railroad station."

He started to close the door, but with unexpected quickness the stout man got his foot and then his body against it. "Take it easy," he said. "Don't be in such a big hurry to turn down good money. I've got a long drive ahead of me tonight, and I'm having trouble with this coupe of mine. It runs oke for a couple of miles, and then it

He made sure it wasn't clogged. Then he took a pinch of gritty dust from the engine bed, sprinkled it on the disks, and called: "Here's your grief."

stops, and it takes me half an hour to get it started again. I never had any trouble with it before tonight. I had to get a guy to push me here. Now I want it fixed so it'll stay fixed, and I want it done in a hurry. I'm a big business man—war work—and I haven't got any time to waste!"

Gus had formed his own opinion of the sort of business his unwelcome visitor probably was in. "No soap!" he said shortly. He again started to close the door, but the stout man kept his weight against it. Gus's temper flared up. "Get out of the way," he snapped, "or I'll . . ."

The visitor's pudgy right hand whipped out a vicious-looking automatic pistol. He jabbed its muzzle into the pit of Gus's stomach—and Gus stepped back from the door. The other's sagging face twisted into a sardonic grin. "Or you'll what?" he snarled. "Get inside there, and be sure to keep your hands where I can see them or you'll get hurt!" He raised his throaty voice a little. "Bring her in here, you!" he called, without taking his hard eyes off Gus.

From outside there came the whirr of a car's starting motor; then a voice from the coupe said: "She still won't run, Pudge."

"Push her in here then, you dope!" the stout man said. He gestured toward Gus with his pistol. "Here, you—get out there and help him."

Jabbed in the small of his back with the pistol every few steps, Gus walked around to the rear of the coupe. A squat man who wore a dark suit and a black slouch hat got out and helped him push the car into the shop. "Lock the door and give me the key," the stout man ordered his companion. He looked suspiciously around the shop. "What's that door?" he demanded.

"It leads into the office," Gus told him.

He opened the door and looked into the office. "Bring a chair over here," he told the squat man. "In front of the door, you dope!" His pistol still in his hand, he sat down and lighted a cigarette. "Now go to it," he told Gus. "Get that car fixed right and make it fast!"

Gus scowled at him, but there didn't seem to be anything he could do but obey. He walked over to the coupe. It was a '41 model of a popular make, but the moment he looked at it in the light he knew that he had seen it before. Trying to remember when and where, he raised the hood. When he looked at the engine he knew. It was Oscar Holcomb's car!

Gus's jaws snapped together. He bent over the engine, pretending to examine it, while he did some hard and fast thinking. Oscar Holcomb was a young engineer who had been employed in the Johnson and Frederick plant on important war work. Late one afternoon a month earlier he had started for a big plant upstate in Millboro for which J. & F. was making parts for a very hush-hush Navy device. He'd never reached the Millboro plant. So far as the police had been able to find out, no one had seen either him or his car from the moment he'd stepped into it in front of the J. & F. office. Gus, who liked the man, had been concerned about his disappearance, and had asked Horner, J. & F.'s general superintendent, about it when he met him downtown. Horner had shaken his head gloomily. "We're worried about what happened to Holcomb, of course," he had said, "but we're even more worried about what has happened to something he had with him when he disappeared. Blueprints and specifications. The Navy people are going crazy worrying about what has happened to them. Fortunately—we hope—the prints and specifications of the little gadget on which the operation of the whole device depends had been held out. But Holcomb could draw it from memory, if he wanted to. The G-men have checked on him, of course, and he seems to be thoroughly O. K. But you never can tell! Keep all this under your hat!"

Gus *knew* that this was Holcomb's car—but he might have to prove that he knew it. How would he do it? He remembered that once when he had been adjusting the fan belt his screwdriver had slipped and made a deep scratch in one of the fan blades. He turned the fan, wiping the edges of its blades clean with his thumb as he did so.

One of them had a scratch in it! Then he asked the thug: "Ever had any trouble with it before tonight?"

Pudge hesitated a moment. "No," he said finally. "It's run fine until tonight."

The squat man cut into the conversation. "Hey, Pudge," he said, "maybe that other feller had trouble with it. We ain't never drove it until . . ."

"Shut up, dope!" Pudge said venomously. "Don't pay any attention to him," he added to Gus. "He's nuts—he never knows the score. Sure—the car always ran fine until tonight."

"What happened tonight?" Gus asked.

"How would I know?" Pudge said. "It just stopped, that's all. That was on the road a little way out of town. We fooled around with it for maybe 15 minutes, and then it started again. It ran all right for about two miles, and then it stopped again. We were close to a garage, so we got a feller to push us in. The garage feller worked on it a while, then nicked me close to ten bucks for the job. Well, the car ran fine for about two miles more, and stopped again. Then we saw your lights, and got pushed in here. I ain't any mechanic, mister, and I want this car fixed so it'll—"

Gus had been doing some hard thinking while Pudge had been talking. "Keep your shirt on," Gus said soothingly. "I'll find what's the matter and have your bus running for you in a few minutes."

"You better!" Pudge said.

Gus had things figured out now, and he went to work in earnest. A quick check showed that the carburetor was dry. There wasn't anything wrong with the fuel pump. He scratched his head reflectively. Then he disconnected the fuel line and at his workbench began to take the fuel strainer apart. He remembered something about that type of strainer. It was formed of thin metal disks through which the gasoline had to pass. He made certain that it wasn't clogged. Then he took a pinch of gritty dust from the engine bed, sprinkled it on the disks, and called Pudge. "Here's the cause of all your grief," he told him.

Still gripping his automatic, Pudge came over to look. Gus pointed out the grit on and between the disks. "That stuff stopped the flow of gasoline to the carburetor, and then of course your engine stopped," he explained. "You can't expect a car to run right if you don't keep it clean."

"Can the advice!" Pudge said unpleasantly. "Say—if that stopped the car some of the time, why didn't it stop it all the time?"

Gus started an explanation, using plenty of technical words. After a few seconds Pudge cut him short. "Oh, skip it!" he said. "Shut up and get the car going."

"Just a few minutes," Gus told him. "I'll blow the strainer out with compressed air—that'll clean it!" He blew the strainer out, put it together, and replaced it on the fuel line. Then he got in the car and stepped on the starter. The engine took off at once.

Pudge came close to him as he got out. "That motor had better keep on running until I get where I'm going," he said threateningly. "If it don't, I'll be back here!" He tossed the door key to his assistant. "Open up," he ordered, and got into the car.

The squat man opened the shop door, and then got into the driver's seat. "That'll be two fifty," Gus said.

Pudge gave him a contemptuous grin. "You're lucky you ain't full of lead," he said. "Get going, dope."

Gus watched the car head north along the empty highway. Then he hustled into the office and dialed the State Police station on the edge of town. Trooper Jerry Corcoran answered the phone.

"Gus Wilson talking," Gus said rapidly. "Remember that Holcomb disappearance, Jerry? . . . O. K. About two miles north on the highway you'll find a dark-green coupe stalled. It's Holcomb's car . . . Never mind now how I know—I *know.* There are two men in it—a fattish fellow, and a sawed-off thug. Pick them up, and maybe you'll find out what happened to Holcomb—and what he had with him . . . Someone tried to get into the J. & F. office tonight, you say? I thought they had—it was this same pair. Watch your step, Jerry—the fat fellow's got a gun, and probably the other one has too . . . No, I'm going home and go to bed. Call me if you need me for anything."

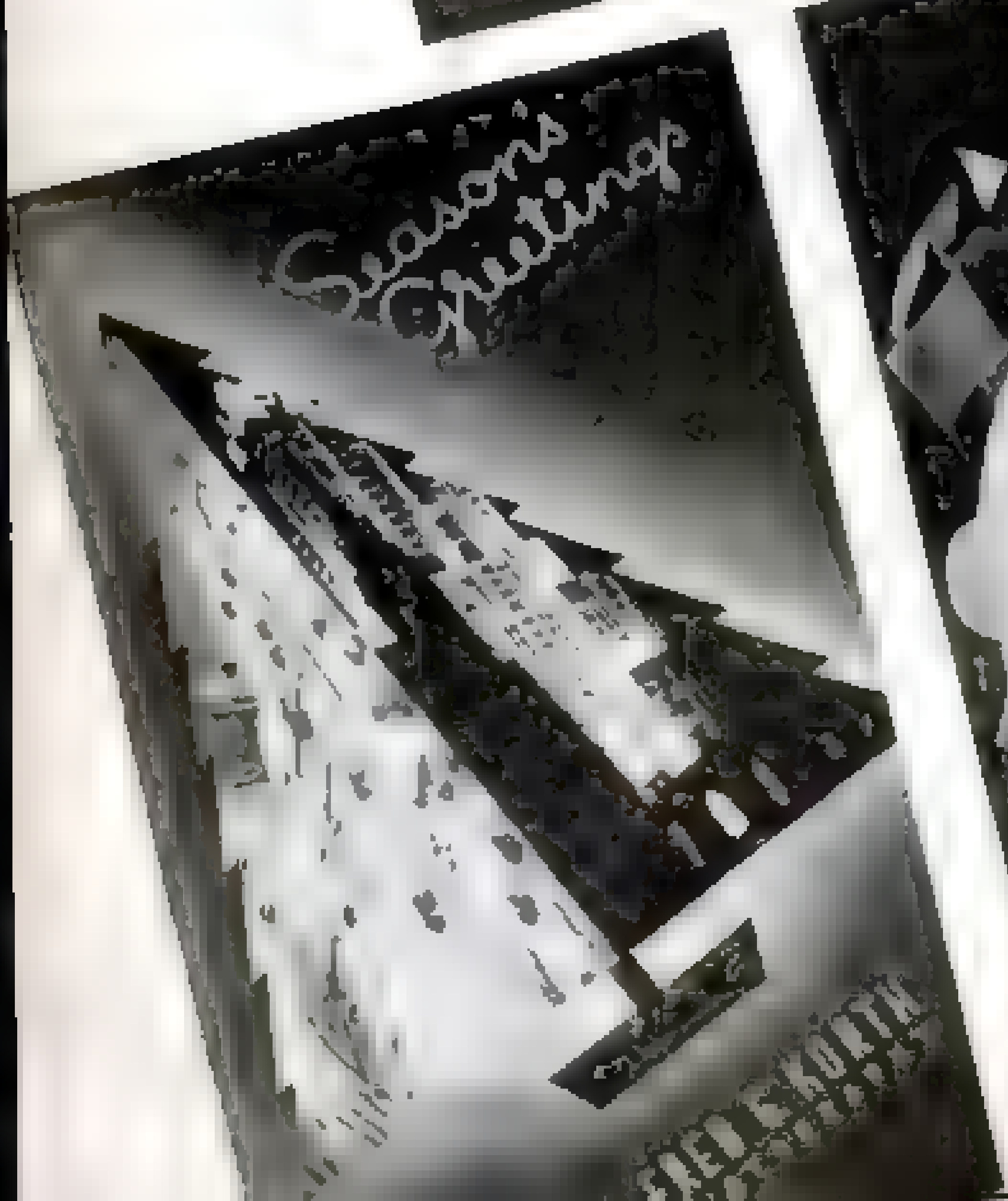
When Gus arrived at the Model Garage the next morning he found Jim McNeil, the local *Advertiser's* reporter, waiting for him. "Some story!" Jim gloated. "The cops found Holcomb a couple of hours ago. He's in pretty bad shape—those *(Continued on page 218)*

GUS SAYS:

Car owners are driving far less than they did a year ago. That means their batteries are getting a lot less juice from generators. It's particularly serious in the winter when batteries get more work to do. Be extra sure to get yours checked and tested often.

Photo

A paper doll Santa taking his own picture was used by Korth as the subject of one of his most amusing Christmas cards. The steps in making the card are shown in the photos on the three following pages. Below at left is a montage of two city pictures cut out in the shape of a Christmas tree. The third card is a comic showing poor old Santa tossed into a waste-basket—a novel better late than never greeting



Christmas Cards

MADE WITH CUT-OUTS

By FRED G. KORTH

DO YOU want something different from conventional Christmas cards this year? Then why not make individualized ones with your camera? Perhaps you have made photographic cards before, but would now like to try something other than scenes showing the family around the tree, the new baby, snowscapes, or Rover lying on the doorstep.

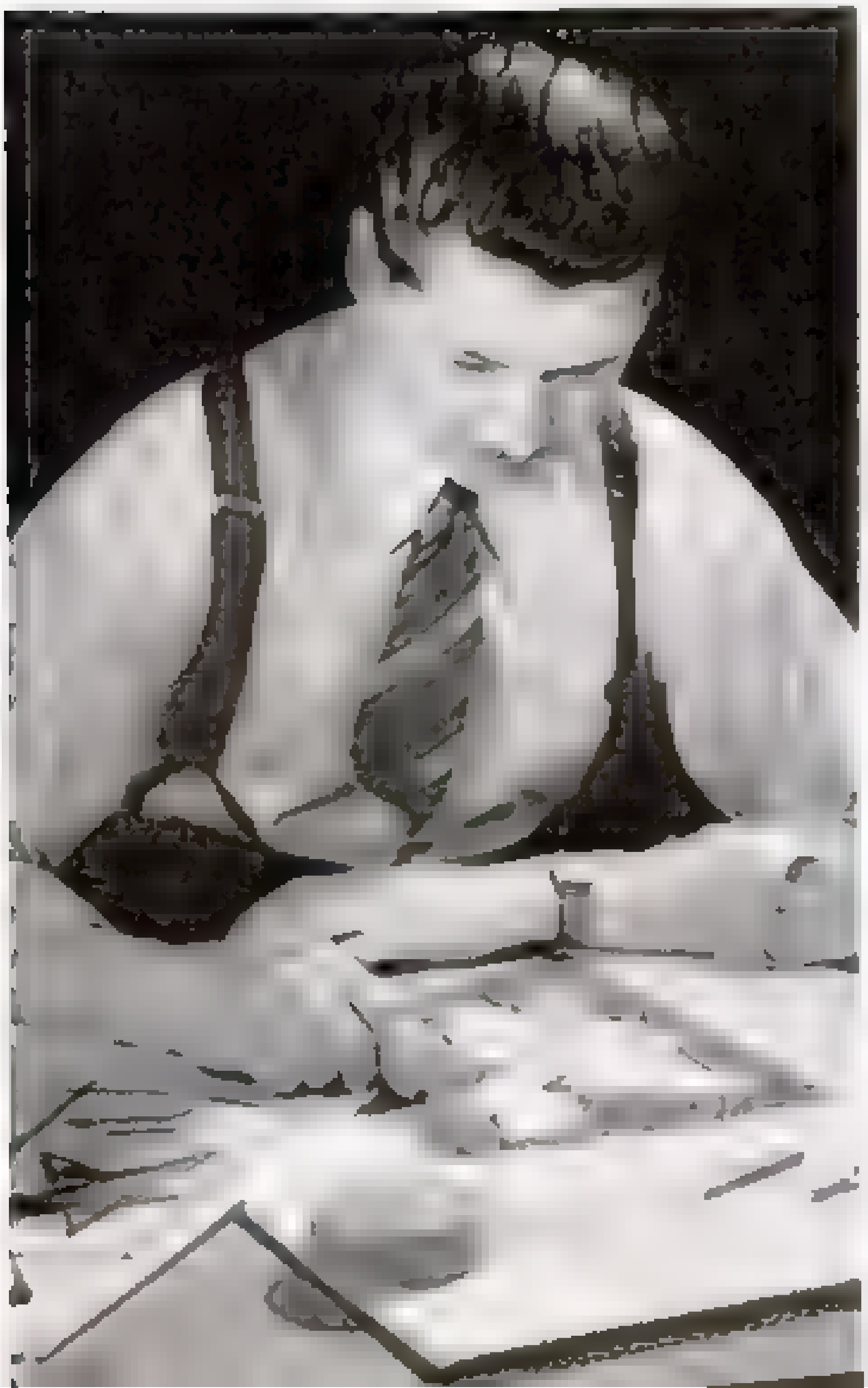
You can make cards of a different and highly original kind at low cost. Three examples on the facing page show what can be done with simple materials.

The first of these shows Santa taking his own picture. Both the model and the props are of paper, but are mounted so as to project from the background, thus producing shadows and a three-dimensional effect. Santa could just as well be peering into a microscope, flying a model airplane, or using a lathe—anything that suggests your hobby or the greeting idea you have in mind.

Designed as a burlesque of the Santa Claus theme, another card combines a cut-out figure with actual objects. It depicts a badly done-in Santa tossed into the waste-basket. This might be appropriate as a belated Christmas card, although the writer merely intended to indicate that he had no very original idea for Santa that year.

The third design—a dignified modern card—is a photo montage of two city pictures cut in the form of a Christmas tree. These were pasted over a black background on which the light area had been applied with an airbrush. The paste-up was then rephotographed, and the cards were printed

Birth and development of a Christmas-card idea. A few rough sketches are first made the size of the finished card; then the best is drawn double size



$25 PRIZE

FOR BEST PHOTOGRAPHIC CHRISTMAS CARD

If you're making photographic Christmas cards this year, why not send one to POPULAR SCIENCE and see whether you can win the $25 we are offering for the best card received on or before December 31, 1942? Entries may show actual scenes, persons, or animals, cut-out or table-top setups, drawings or photo montages, models, or any other subjects, but the cards must be made photographically—a camera and film must be essential to the process you use.

Cards must be of original design and the work of amateurs. Professional artists and photographers are barred, as are also employees of POPULAR SCIENCE and their immediate families. No entries can be returned, and the editors' decision is final.

Pencil your name and address on the back of the card. A few words telling how it was made may be added. In case of a tie, duplicate prizes will be awarded. Address the Photo Editor, POPULAR SCIENCE, 353 Fourth Avenue, New York, N.Y.

or enlarged from the negative so made.

The possibilities, as will readily be seen, are enormous. They include both two- and three-dimensional effects. And so many interesting combinations of silhouette work, plastic modeling, typography, straight photography, and the personal handwritten touch are practicable that even the fourth-dimensional world of surrealist art seems to come within the range of your camera.

Once you have an idea, the first step is to sketch it on paper the actual size the finished card is to be. Figures can be original or copied from cartoons, photographs, magazines, and other sources. Probably you will want to try several sketches, changing the props and the composition. Redraw the best one double actual size.

This will serve as a guide in making the figures. Lay them out on heavy drawing paper, which is strong enough to retain its shape when bent. Bending the various elements of a figure is what gives animation and perspective, and produces expressive shadows. For example, Santa Claus' right arm in the first example is bent forward over his stomach. His mustache is formed by slitting a strip of paper at intervals and curling the fringe so formed. The tassel of his cap is bent over toward the front.

Details such as the rim of the cap, eyebrows, shading on the cheeks, and so forth can be drawn in with black pencil or India ink.

Cut the figures out with scissors. A stencil knife is handy for cutting intricate parts, such as the fingers, the slitted thumb of the hand that holds the film slide in the card shown, and the slit for Santa's nose, in which a small piece of paper was later inserted. The cigarette shown in one of the accompanying photographs served as the lens tube of the camera, and the screw became Santa's open eye. A single piece formed the camera and tripod; the rectangle was bent sharply back to form the boxlike body. In this case a piece of string became the "rubber" tube Santa holds in one hand to snap the shutter.

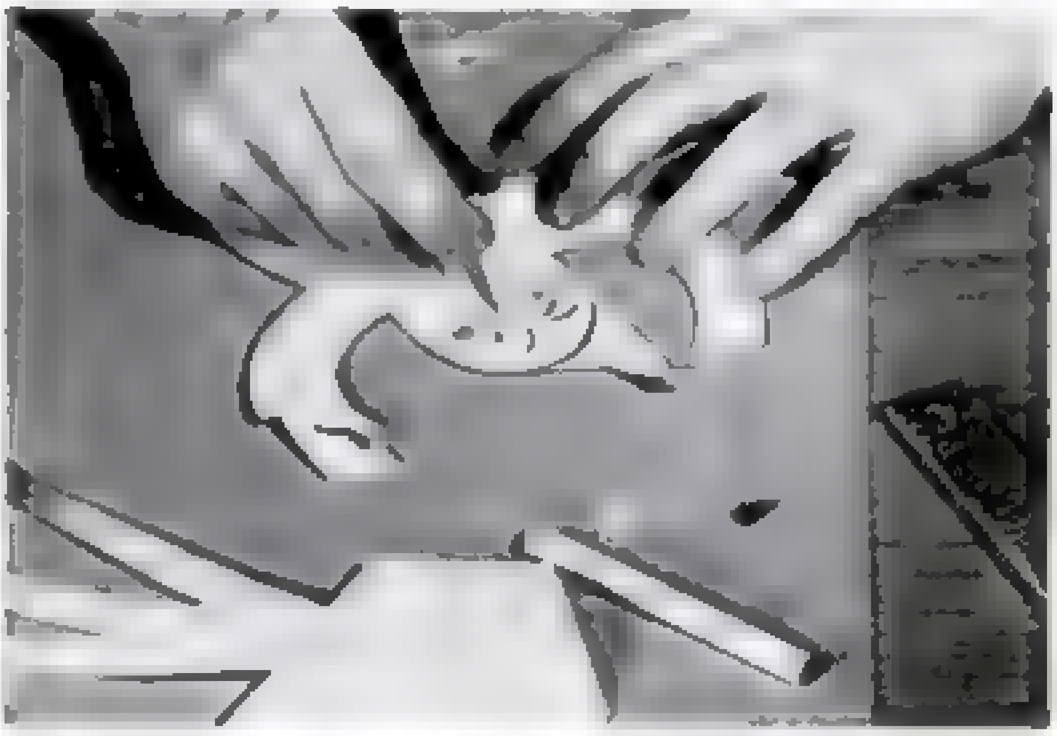
Another photograph shows the setup ready to be shot. A large piece of gray cardboard was laid on a low platform, and the figures were arranged on it according to the original sketch. The tripod legs lay flat on the background; the paper camera was held slightly above the cigarette by a bit of modeling clay. Santa's body was similarly raised above the paper by a small block of wood.

The setup was illuminated by one main light, which produced deep shadows to one side and in back of each cut-out, and by a second weaker lamp lower down that lit up the top of the paper camera somewhat.

Such arrangements can be photographed with any camera, but one having a focusing back is to be preferred, as the lighting and composition can be better studied. Almost any type of film can be used. Exposure-meter readings should be taken on the high lights or white objects. A spotlight is ideal for illumination as it enables one to light up the subjects brilliantly and leave part of the background dark for the sentiment and name.

If the negative is smaller than 4" by 5", the cards can be printed from it by enlargement, or a copy negative of suitable size can be made from it. A 4" by 5" or larger negative, on the other hand, enables one to make good-sized contact prints easily at low cost.

The figures and accessories are next laid out on heavy drawing paper—with allowance for bending—and cut out



A stencil-cutting knife or other sharp blade is used for the finer cutting and to make slits, as for Santa's nose

The setup ready for photographing. A bit of modeling clay supports the paper camera above the cigarette that forms its lens, and Santa's body is raised on a block of wood. The background is a sheet of gray card

The sentiment and signature can be produced by several methods. They may be written on the celluloid side of the negative with opaque ink, or lettered on the setup in white or black before it is shot.

Still another method is to have it set in type, as was done for the first Santa Claus card illustrated. A proof of the type matter is made by the printer in black ink on white paper. This proof is then photographed on process film to precisely the same scale as the picture material and in exactly the relative position it is to appear on the cards. The process negative resulting will be a solid black film with transparent lettering on it.

The film with the wording is put into a printing frame in contact with another sheet of process film and exposed. The positive should be perfectly transparent with opaque black letters. To produce the illustration and the lettering on the same print, bind the picture negative and the lettering positive together with tape at the edges, and print from both at once by contact or enlargement.

A good glossy-black background for greeting-card setups can be made of double-weight sensitized paper. Expose a sheet at least 8" by 10" to bright light; then develop, fix, and wash it in the usual way. Such a background may be used effectively for montage arrangements on which the name and greeting are hand lettered.

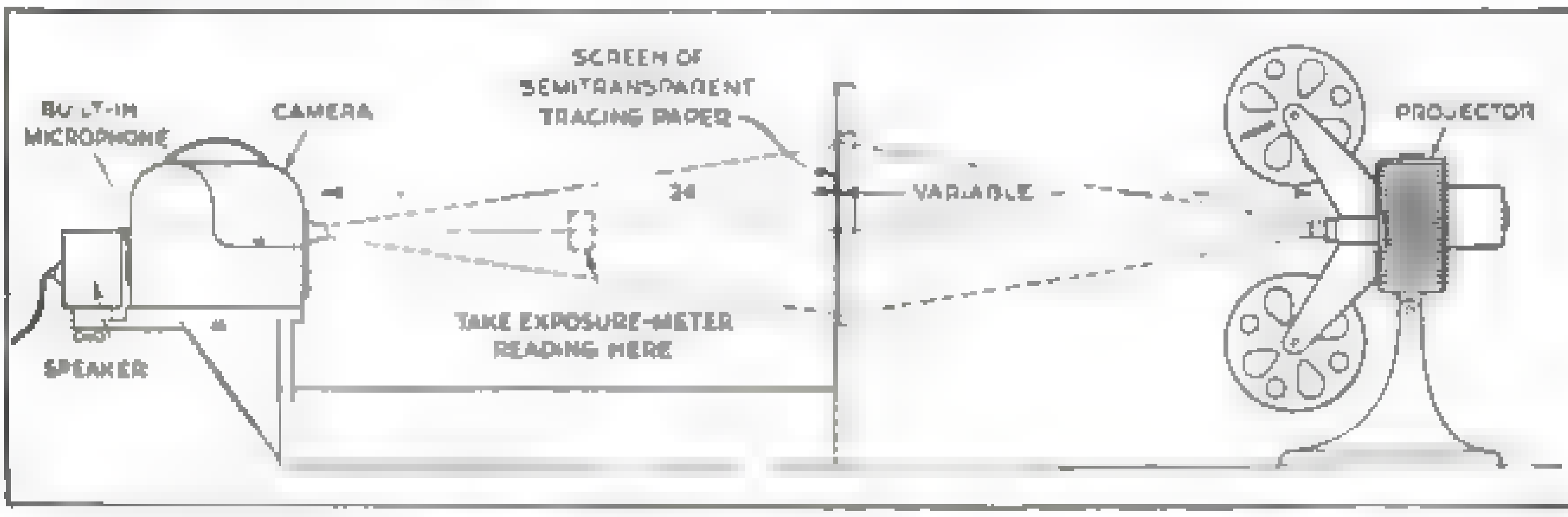
While obviously ideal for personal greeting cards of distinction, this type of photography has many other applications. It has been used to make advertising pictures, magazine covers, and many other kinds of illustrations. The dramatic effects possible are limited only by the photographer's imagination and skill.

Paper Screen Aids in Process Projection

STRAIGHT copies, sectional enlargements, reductions from 16-mm. to 8-mm. home movie film, and enlargements from 8-mm. to 16-mm. film can be made easily with a semitransparent tracing-paper screen. Cement a 9" by 12" sheet of the paper to a simple cut-out easel as shown in the drawing. Set the projector to throw a 6½" by 8¾" image on this, or as much of the frame as is to be copied.

I use a 500-watt or a 750-watt bulb, depending upon the distance from the projector to the screen. Also, a reading should be taken with an exposure meter.

The device blows up small areas for close-ups and provides moving backgrounds for titles. For good titling results, I first photograph white letters on black velvet, backcrank the exposed footage, and photograph the desired scene on it. For copying with a sound camera, a narrator talks into a microphone.—CLARENCE N. ALDRICH.



Glass Jar Keeps Print Tongs Handy

TO PREVENT print tongs from being contaminated by solutions or chemicals spilled on the table, keep each pair in a small glass jar. The jars hold the tongs upright so that they can be seized instantly, and if a small amount of water is kept in each jar, the tongs will automatically be rinsed after each use.—LOUIS HOCHMAN.

Replacing Tank Agitator

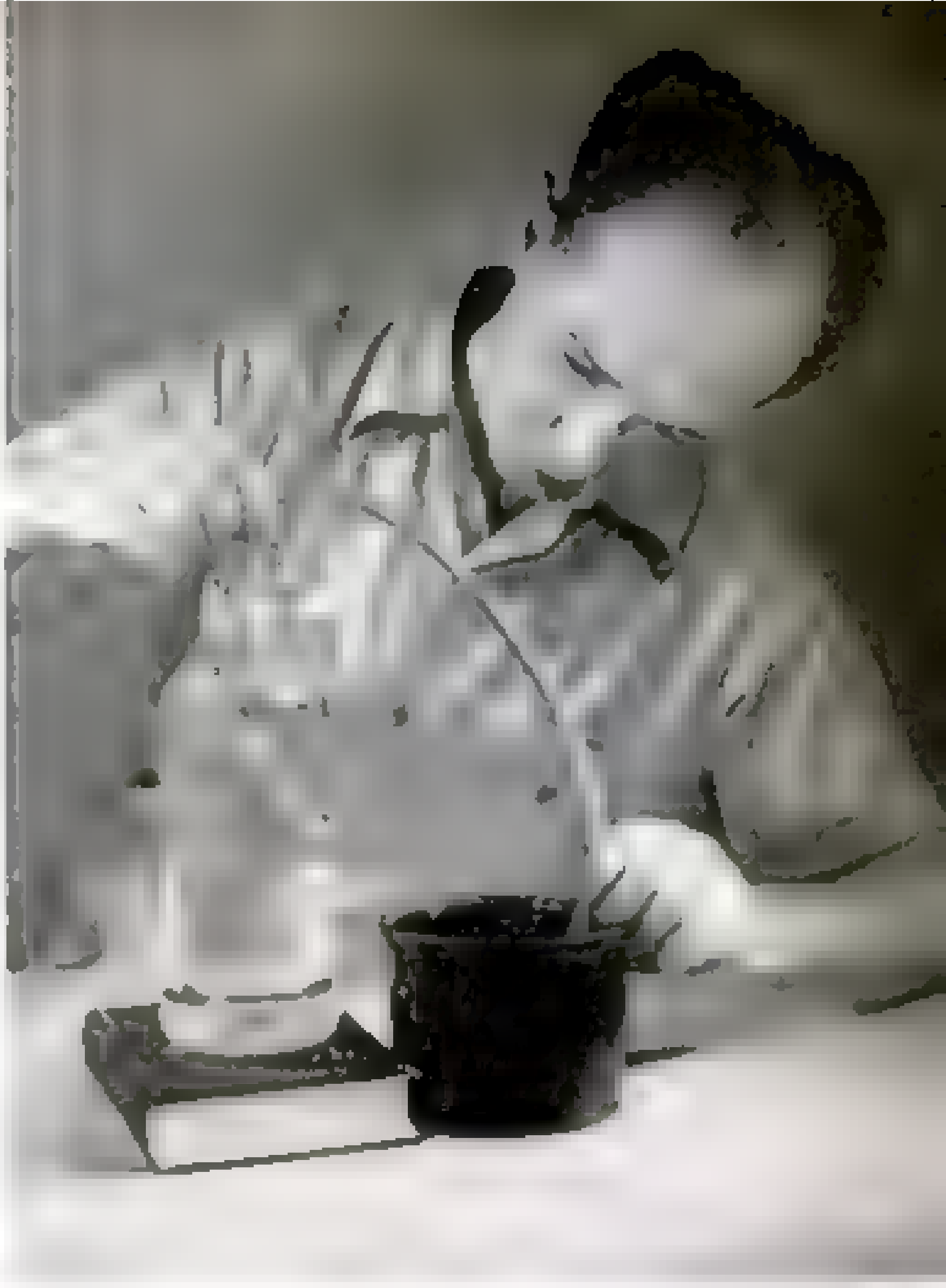
WHEN the agitator of a developing tank is lost or mislaid, a celluloid toothbrush handle can easily be made to serve in its place. After cutting off the bristle end, file a notch of suitable size in the cut end so that it will engage the reel.—OLIVER BANDELIER.

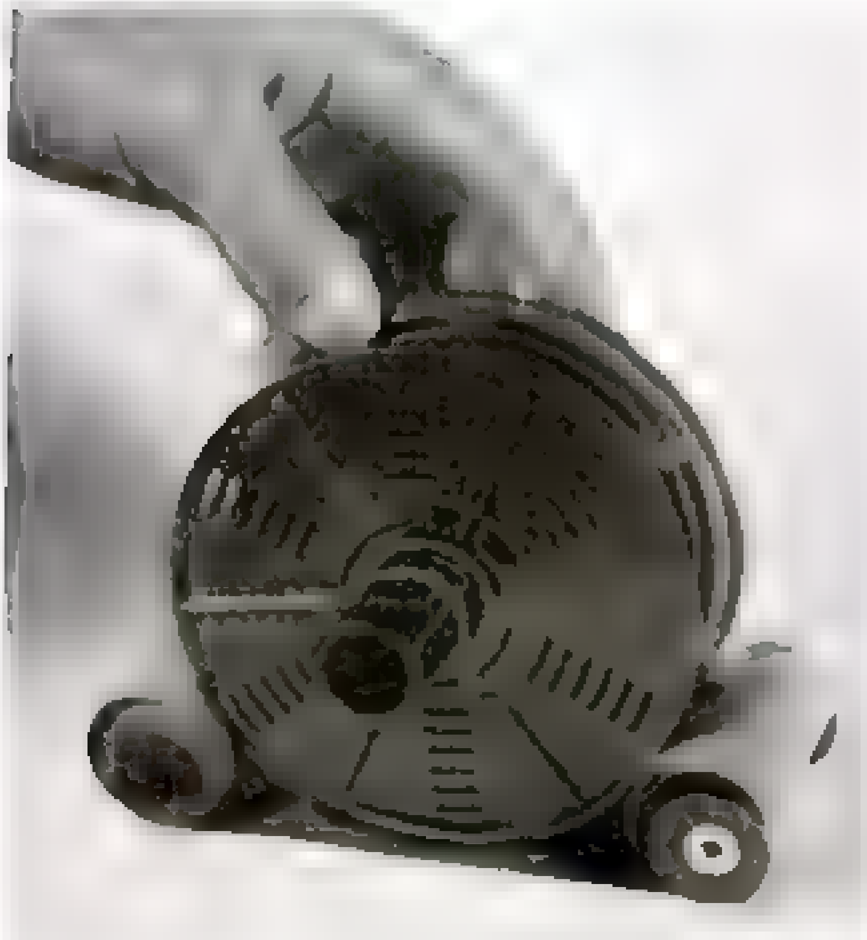
Developer Siphoned into Tank to Save Time in Filtering

PHOTOGRAPHERS well know that film developer used more than once should be freed of accumulated sediment before it is poured into the tank. A method that avoids the time-consuming process of filtering is to siphon all but the last ounce or two of developer from the storage bottle into the tank, leaving the sediment on the bottom of the bottle. In case a rubber tube is not available, use a U-shaped glass tube.

Flash Bulbs Removed Safely with Cardboard Jacket

MANY fingers have been burned because eager photographers couldn't wait for a fired flash bulb to cool before they tried to remove it. It's easy to take the bulb out of a socket if a cardboard wrapper or jacket such as all flash lamps are packed in is first slipped over the hot glass to insulate the fingers from it.





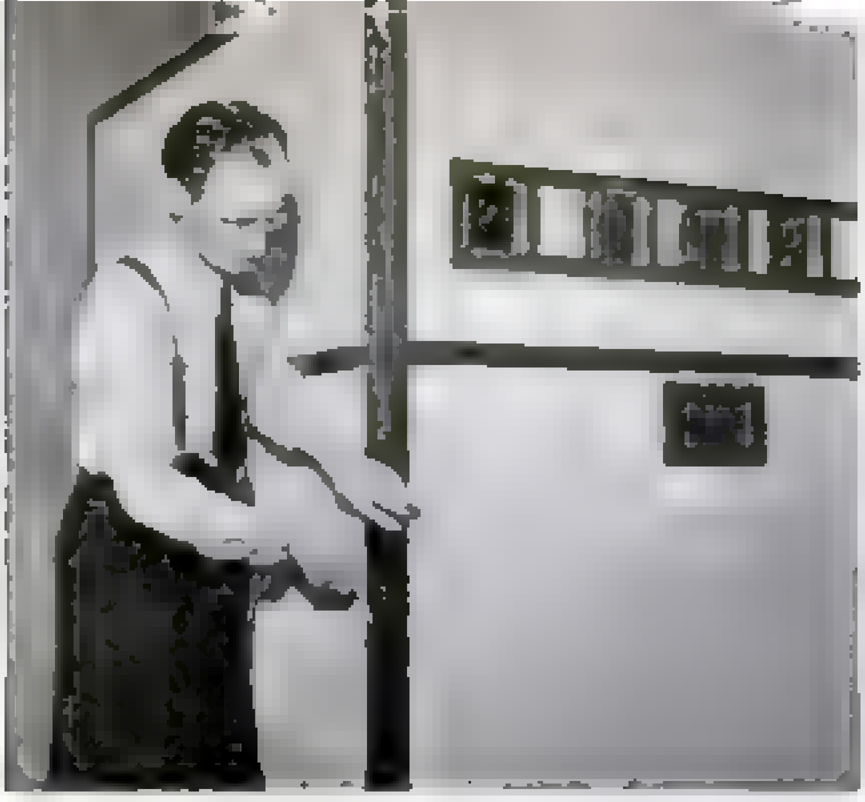
Rinsed Developing Reel Dries on Film Backing Paper

THE backing paper from a used roll of film forms an excellent cradle on which to drain and dry the reel from the developing tank without having the rinse water drip on the table. The coiled ends of the paper keep the reel from rolling away and perhaps being broken.—E. A. BOWER.

Thermometer Marks Renewed with Lampblack Treatment

IS THAT metal thermometer you have been using in your developing solutions (particularly those containing caustic) hard to read because the enamel filling of the engraved markings has become loosened and fallen out? You can easily restore its legibility by coating the etched markings with thick lampblack ground in oil and then wiping the surplus off with a cloth. Let it dry well before using.—GEORGE S. GREENE.

Worn etched markings of a metal thermometer become legible if coated with lampblack ground in oil



One man can set up this three-walled booth in two minutes. The walls consist of sound-absorbent wall board fitted into a frame of grooved strips

Two, three, or four projectors may be operated on a projection shelf, built as shown on the facing page. There is room also for a sound turntable

Portable Projection Booth

FOR showing civilian-defense films at various points in their community, members of the Long Beach, Calif., Cinema Club use a portable three-walled projection booth that eliminates most of the difficulties encountered in home-movie setups. Within its lighted interior the operator can work unhampered by darkness, talk in normal tones to an assistant, and control the house lights. By making possible the use of two, three, or four projectors, the booth eliminates that awkward wait between reels. Last but not least, it keeps curious folks in the audience off the operator's neck while he is busy entertaining them.

The walls consist of sound-absorbent wall board fitted within a framework of 1⅝" square strips. All three walls are 4' 11¾" wide and 7' 1" high. A 4" open space is left at the bottom for ventilation. At the joining edges of the walls and front, butt hinges are attached. The pins of these are removable, so that the booth can be assembled or dismantled quickly. Should conditions require a rear wall or roof occasionally, a cloth flap will serve.

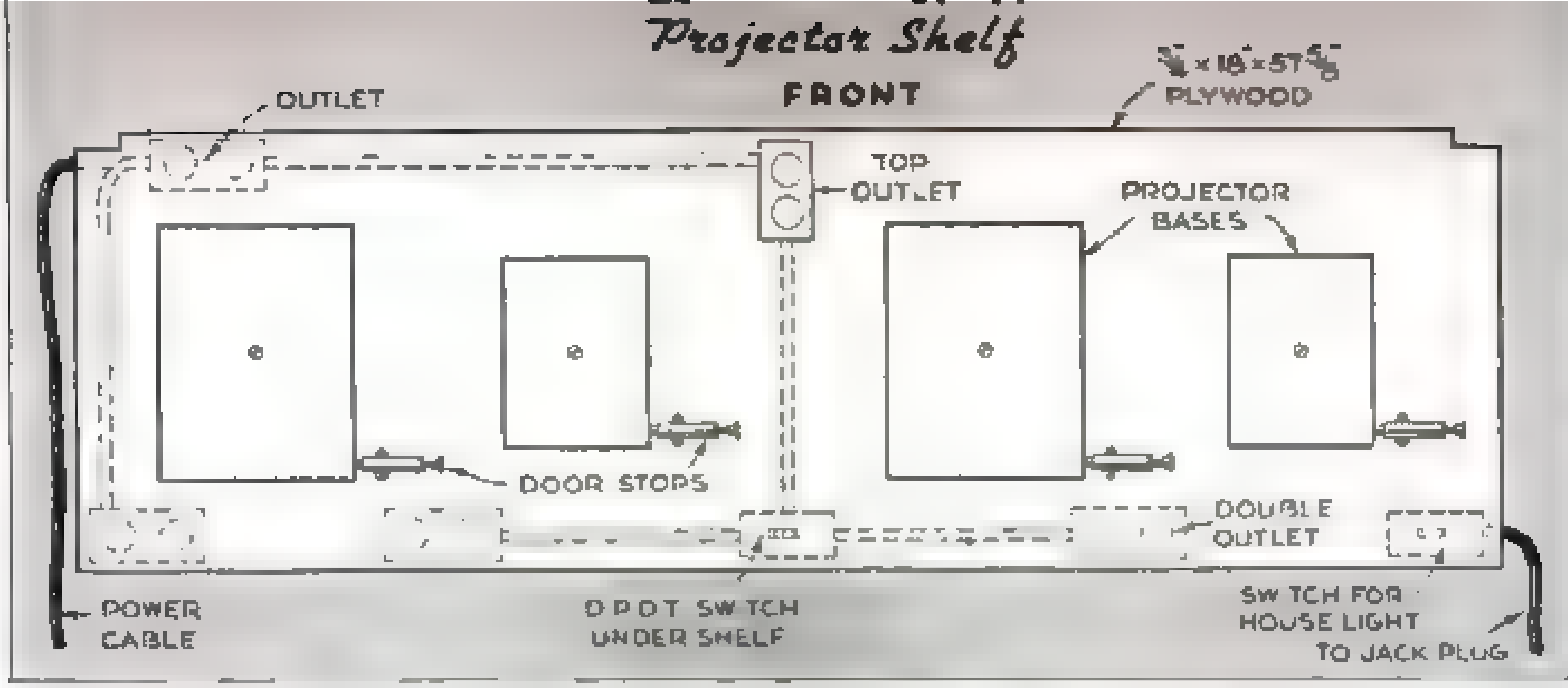
Have grooves cut lengthwise in the exact center of the frame pieces at a lumber mill. They should be of such a width that the wall board will fit into them snugly. Do not paint the board, but two coats of size may be applied for strength without impairing sound absorption.

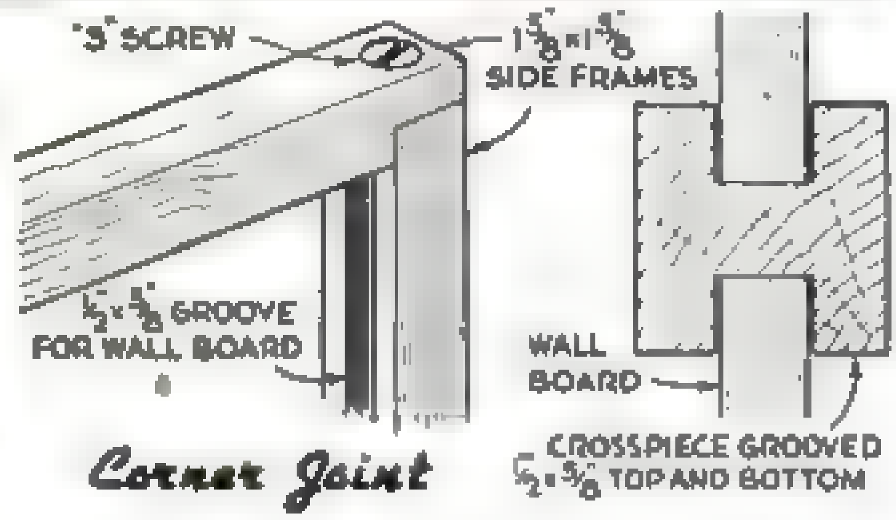
With a keyhole saw, cut five ports in a row in the front wall. Immediately below the center one, cut a sixth slightly larger for the sound operator to see the screen while seated. Good-quality plate glass or old photographic plates, puttied in place, make satisfactory windows, but tilt them downward slightly to minimize reflection.

A projection shelf rests on the three cross members. On it is mounted a swivel base for each camera. Nail framing strips around the base to hold the machine snugly. The pivot is a carriage bolt, with a washer and wing nut below the shelf. Glide casters affixed underneath will reduce friction. Fasten an ordinary door stop alongside each base and attach a coil spring to the underside to keep the base pulled against it. After lining up the projector, push the door stop against the base. The camera will thereafter be aligned automatically if it is swung against the stop.

Attach a long, heavy-duty cable permanently to the underside of the shelf to reach distant electric outlets. Mount three double outlets for pilot lights, one of them on top to provide

Butt hinges with removable pins at all joining edges will make the job of assembling or dismantling simple





enough illumination for the projection shelf.

Install a double outlet for each two projectors. The current is fed to either outlet through a double-pole double-throw switch. By throwing this, you stop one projector and start another, making the transition between reels smoothly and quickly. If you use both 8-mm. and 16-mm. projectors, plug one of each into each outlet.

For control of house lights, the ordinary house wall switch must be fitted with a jack-plug socket. A cord runs from this to another switch mounted under the projection shelf. A rheostat may be cut in for dimming the house lights from the booth in professional fashion.—HAROLD O'NEAL.

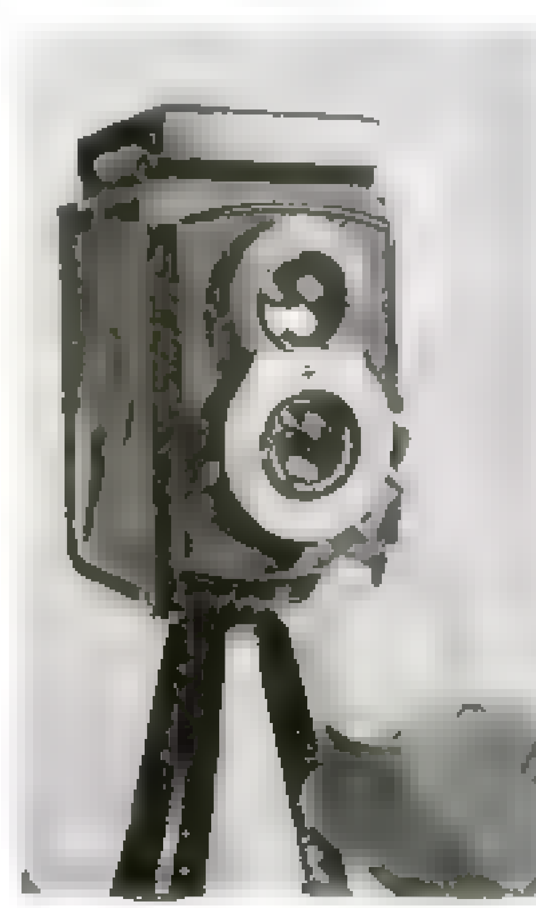
Helps in Using Reflex-Type Cameras on a High Tripod

MINOR inconveniences in the use of a reflex-type camera on a high tripod, such as in focusing or in adjusting the speed and stop settings, can frequently be overcome with simple accessories devised at home. In the case of focusing, a small pocket mirror held at a 45-deg. angle over the ground glass will reflect the image at eye level, following somewhat the principle of a simple periscope. A sheet of light cardboard can be folded into a suitable hood to slip over the camera hood and hold the mirror at the proper angle, as shown in the first photograph at the right.

The construction of one of the reflex-type cameras, the Rolleiflex, is such that the speed and stop settings are visible only through a small opening in the top of the lens housing. This often makes it hard to set the lens and shutter when the camera is mounted high. A removable, auxiliary set of speed and stop markings, as shown in the other photograph, is a help. Cut a piece of heavy, white paper to fit snugly over the lens collar, and on this mark the settings to coincide with the positions of the adjusting levers.—LOUIS HOCHMAN.

Set up over the ground glass, a small mirror reflects the image when the camera is held high

Removable, auxiliary speed and stop markings on white paper are an aid on the camera below



HOME and WORKSHOP

PICTURE PUZZLE BOARD

By ELMA WALTNER

FOR children too young to master jigsaw puzzles, this picture board will prove an entertaining and educational toy. Fitting the various animals into place proves a fascinating task for little ones from two to four years old. At the same time, it teaches them eye and muscle co-ordination.

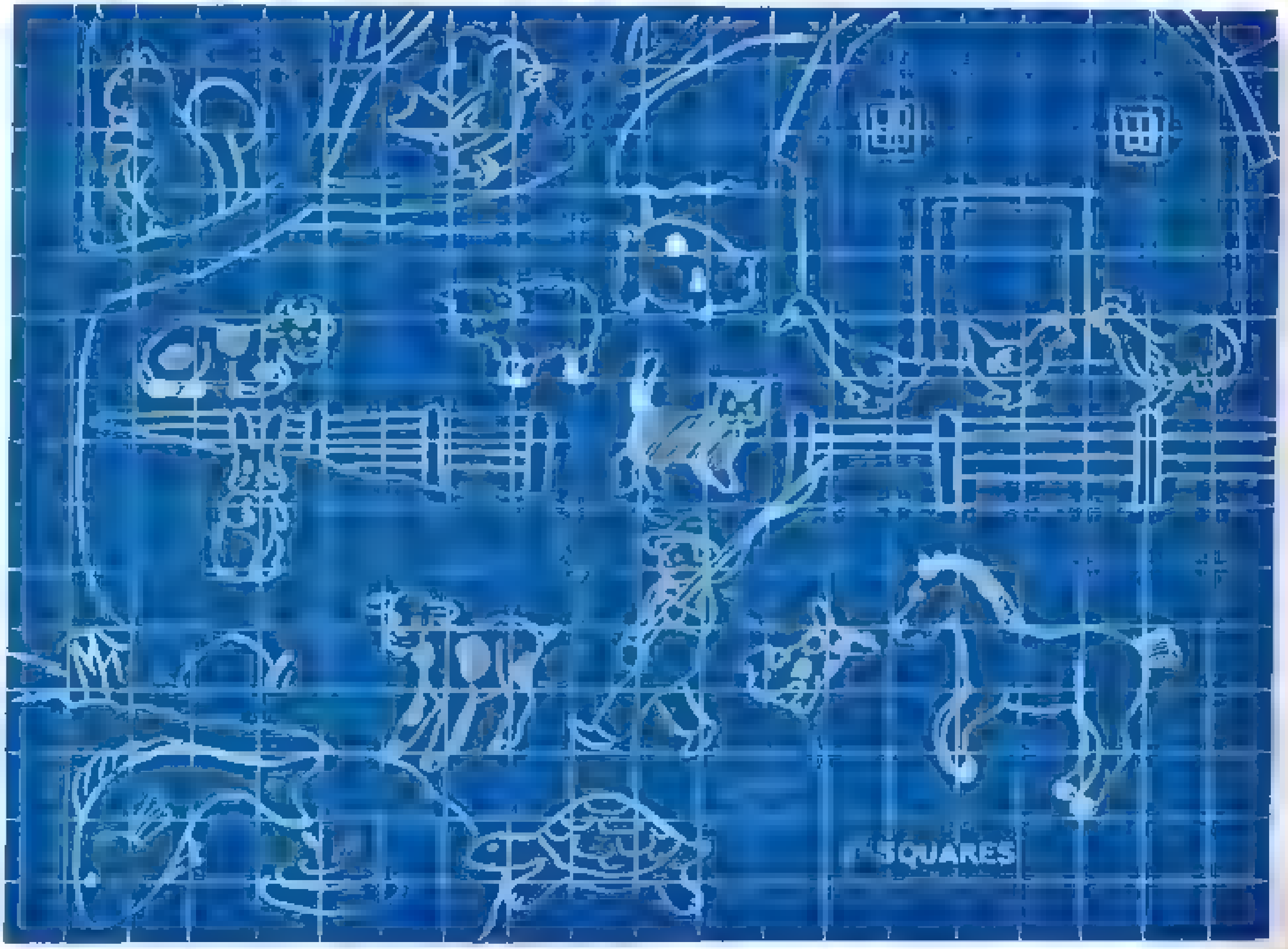
The board measures 15" by 20". Lay out the picture on paper by drawing it on 1" squares, and transfer the pattern with carbon paper to a piece of ⅝" pine plywood. Drill a small hole near each outline to allow a fine jigsaw blade to be inserted.

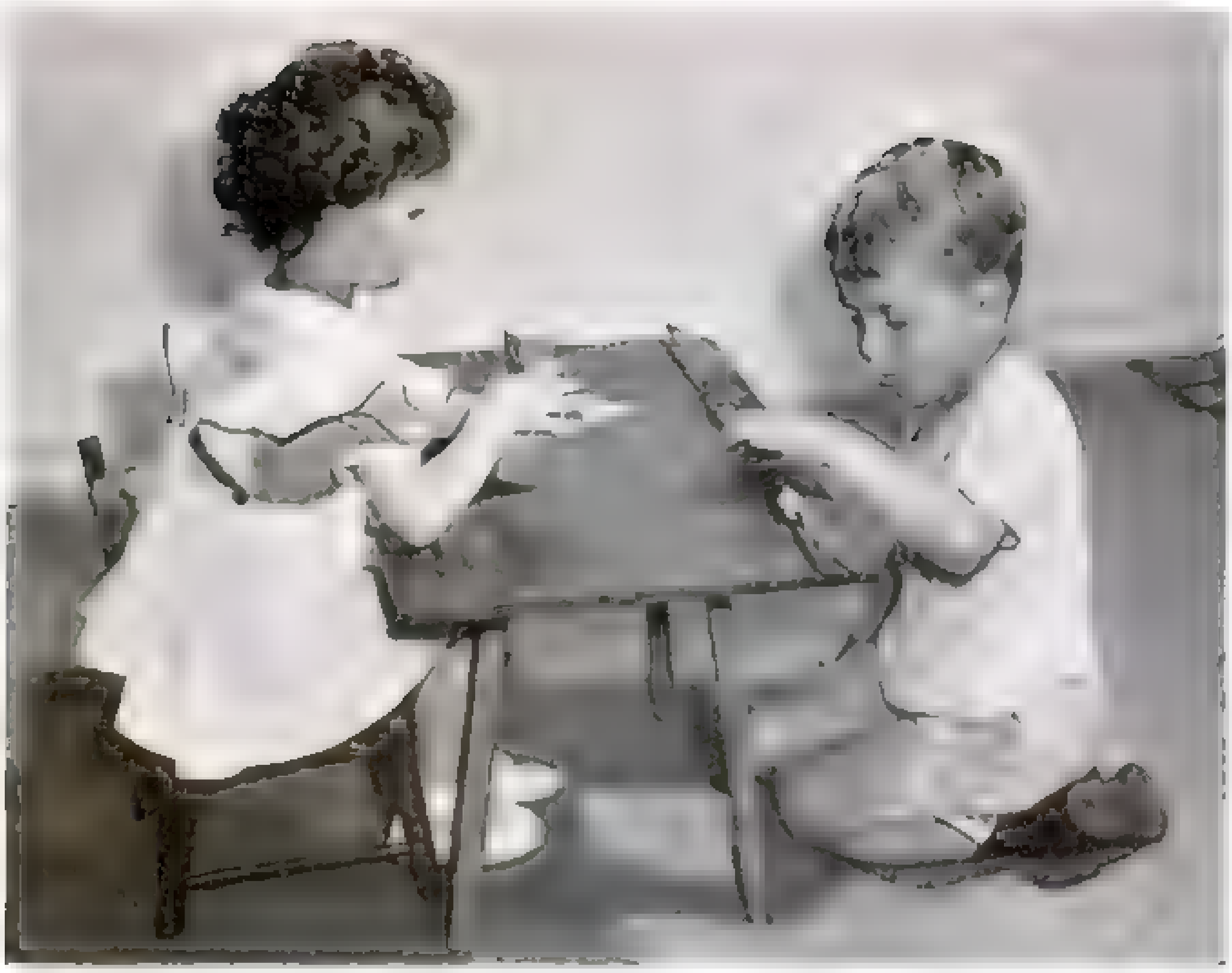
Saw out each of the figures carefully, being sure that the cut is vertical at all times. In the case of the little boy, the upper part of the fishing pole is painted on the picture background instead of being sawed out. The cut across the pole is made at the boy's shoulder. When the piece is in place, the break is hardly noticeable.

The cut-out picture board is fastened with glue or small brads to a ⅜" or ¼" plywood backing board of the same size so that the figures cannot fall through the openings.

Paint the background and the figures with quick drying enamels. Paint only the top surfaces of the figures, not the edges, so that they will not stick in their places.

The figures can be painted to suit or as follows: Squirrel, gray-brown; bird, red; cow and calf, white with black spots; rabbit and lamb, white; pig and dog, tan with black spots; goose, gray; hen, tan with red comb; rooster, tan with brown tail, red comb and wattles; cat, black with white face and stockings; boy, blue pants, white shirt, yellow hat; horse, dappled gray with black mane and tail; fish, blue-white; turtle, gray-brown; fence, white; barn, red with white trim and green roof; haystack, yellow-tan. Markings and outlines may be in black.





Colored beads on the wire rack and geometric designs add eye appeal to this child's table

Small Play Table and Chair

By ERNEST R. DEWALT

CONVENIENT and useful, this play table and chair can be adapted to many needs of eating and playing. A colorful bead rack and geometric designs on the table add that eye appeal which is so essential to encourage children in the manipulation of colors and forms.

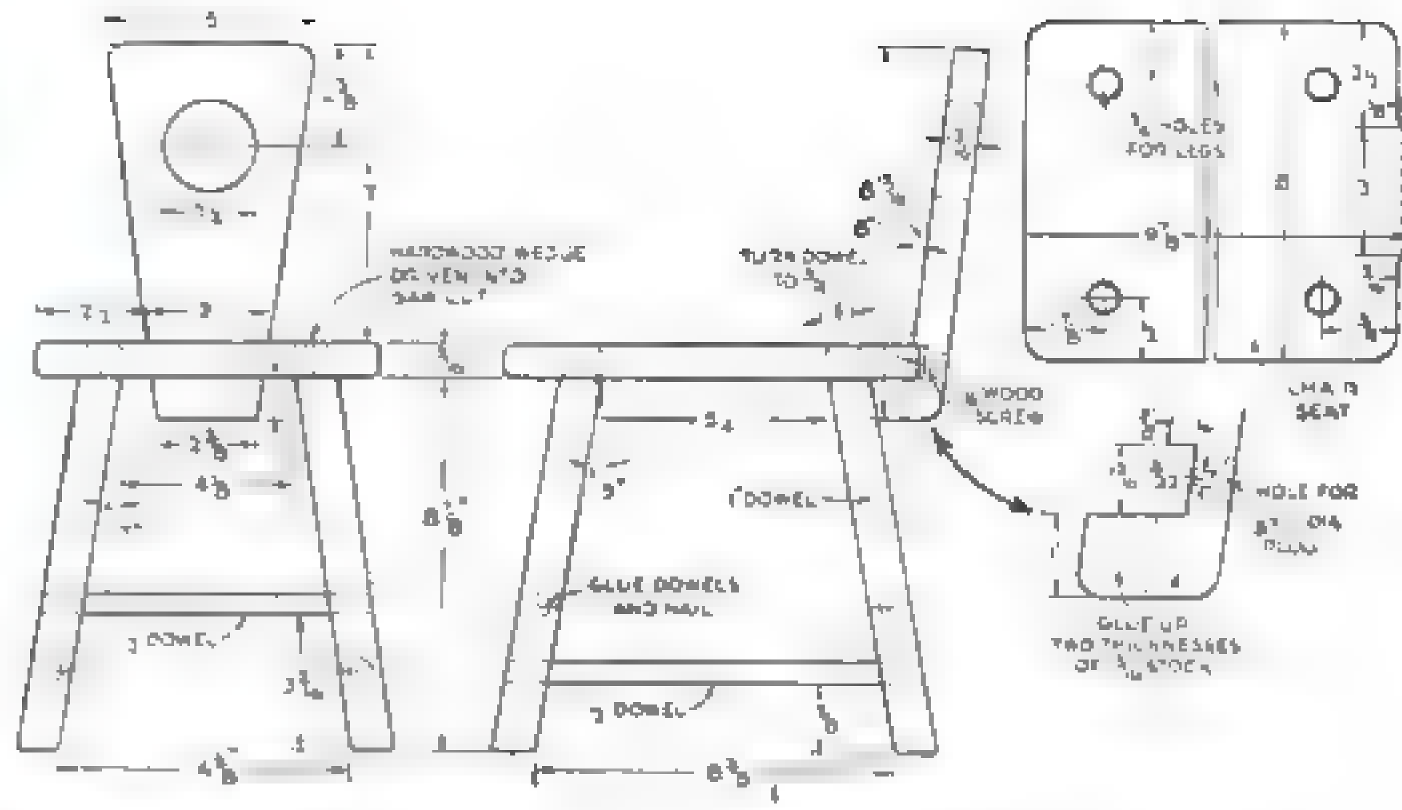
Table. The two legs are secured to cross braces and the table top, making the piece collapsible in construction and easy to store away. The plywood top is 1/2" by 16" by 22", with all corners rounded.

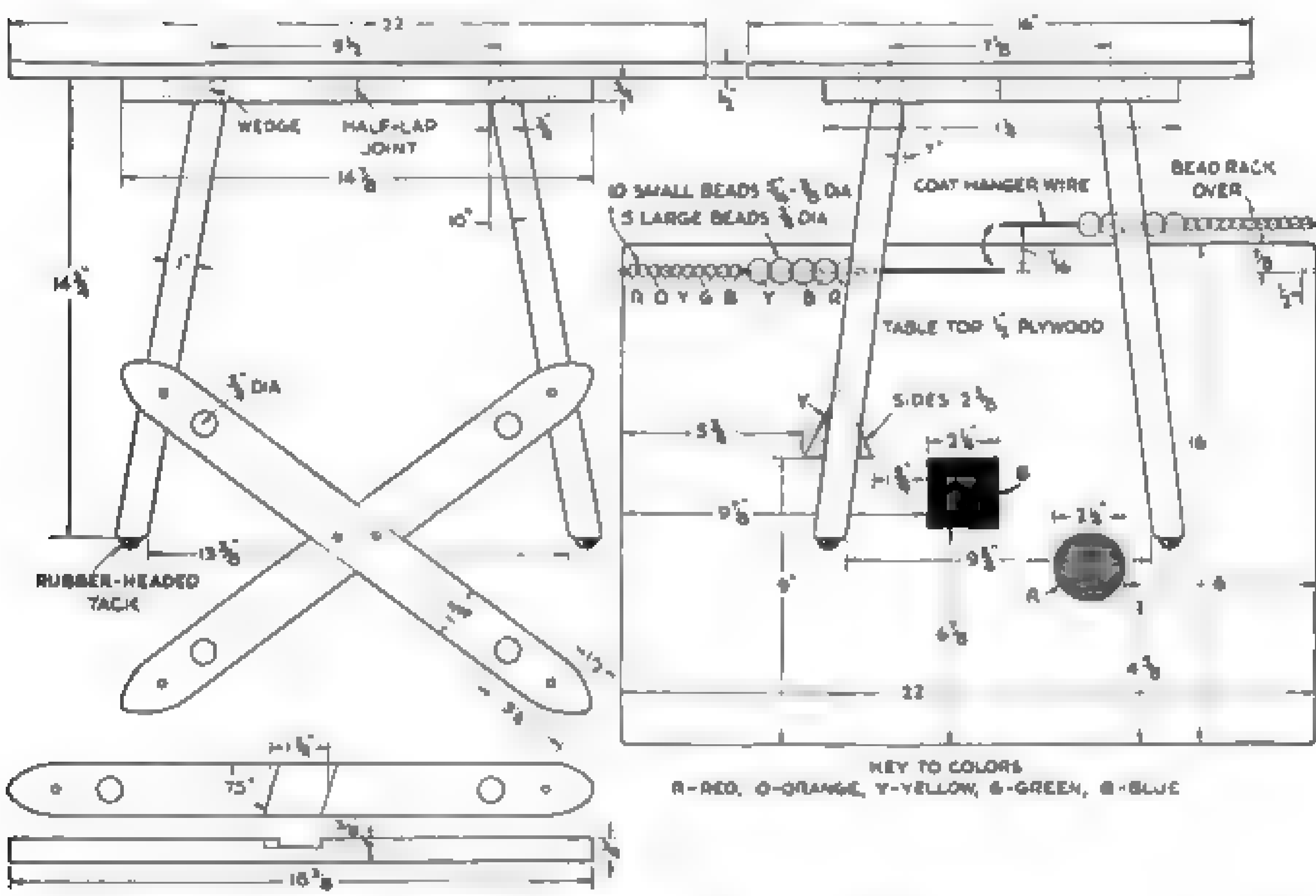
The bead rack, which pivots out of the way when not required, is made from coat-hanger wire. String on it 10 large and 20 small wooden beads, varied in color; these are obtainable in most five-and-ten stores. Arrange the beads in the pattern shown to make an abacus which can be used for counting, or for any game the nurse or parent may devise to instruct a small child.

Added visual interest is given to the design by stenciling a triangle, a square, and a circle on the table top in yellow, blue, and red, respectively. Cut a stencil for each basic form, keeping to an overall 2 1/4" size, and space as directed in the drawing

Two braces of 3/4" by 1 3/4" whitewood are 18 3/4" long, rounded at the ends as shown. Cut a half-lap joint at the center of each brace, making an angle of 75 deg. Drill 3/4" holes 3 3/4" in from the ends and 9 1/2" apart on centers at an angle of 10 deg., so that the legs flare out. Small screw holes are drilled 1 1/2" from the ends of the braces on the center line for joining the braces to the table top.

The legs are of 1" maple dowels turned or whittled to 3/4" pegs on top to give a height of 15 1/4" to the table top. Rubber-headed nails or casters will then raise the table approximately 1/4" more to an overall 15 1/2" height. Slit the pegs with a back saw for hardwood wedges at the peg joints.





Finish: Stain the top green and wipe dry. Apply two coats of clear varnish, rubbed between coats. Give the legs two coats of clear varnish, rubbed down, and apply wax. The red used in the circle is similar to the red used in the inner rim of the circle of the play chair.

Chair. Whitewood 13/16" thick is used for the seat and back. The 2¼" hole in the back is jigsawed and lightens the design and serves as a cut-out handle. The back is joined over and centered on the rear of the seat with two 1¼" wood screws covered with ½" dowel plugs.

The legs are 1" maple dowel stock, turned down or whittled to ¾" at the peg joints. The pegs are slitted for hardwood wedges. Four side braces of ½" dowel are driven into ½" holes drilled through the legs; these braces are lined up 3 3/16" and 1⅝" from the bottom as shown. Clinch these joints with ¾" brads. The height from floor to seat top is 9⅜".

Finish: Round all edges of the seat; sand corners after cutting curves. Paint the legs green, the inner rim of the cut-out circle, vermilion. Apply two coats of varnish to the seat and back, and wax.

Working time: table, 5 hours (minus drying time); chair, 4½ hours.

Maple stain, painted interior, and metal ornaments make this an attractive piece

Easily Built Pine Chest Holds Large Assortment of Toys

By CARL F. H. SCHRADER

THIS toy chest should appeal to a father who wants to build something practical and attractive at a comparatively small outlay. No great amount of skill is required in its construction, nor are power tools needed. The chest could also be used for a variety of other purposes—a hope chest, tool chest, or linen box—and, of course, the dimensions can be varied to suit individual needs.

The wood is well-seasoned No. 2 white pine, with or without knots. The corner joints merely overlap and are nailed together. Decorative designs cut from old tin-can metal or scraps of galvanized iron conceal these joints effectively and add a distinctive touch to the project.

Cut the stock to size. The 12" width comes commercially about 11⅝" wide, so very little planing will be needed to true all the widths to 11¼". Rip one of the 36" long pieces to supply the narrower stock needed to piece out the lid and bottom.

The feet are attached to the bottom after the two crosspieces or battens have been fastened to hold the bottom lengths together. Then the four sides, which have previously been nailed together, are set upon the bot-

LIST OF MATERIALS

No. Pc.	T.	W.	L.	For
5	[illegible]	12	36	Lid and bottom
2	[illegible]	12	15½	Sides
4	[illegible]	2	15½	Battens
4	[illegible]	3	9	Front and rear feet
4	¾	3	6	Side feet

Note: All dimensions are given in inches.

tom, and eight small metal angles are used to secure them to it.

Like the bottom, the lid has two crosspieces screwed across it. This type of construction eliminates doweled and glued joints, and with seasoned wood has been found to be very effective. A shallow tray or narrow shelf may be added, if desired, to hold small toys; it should be mounted near the top of the chest, at the back.

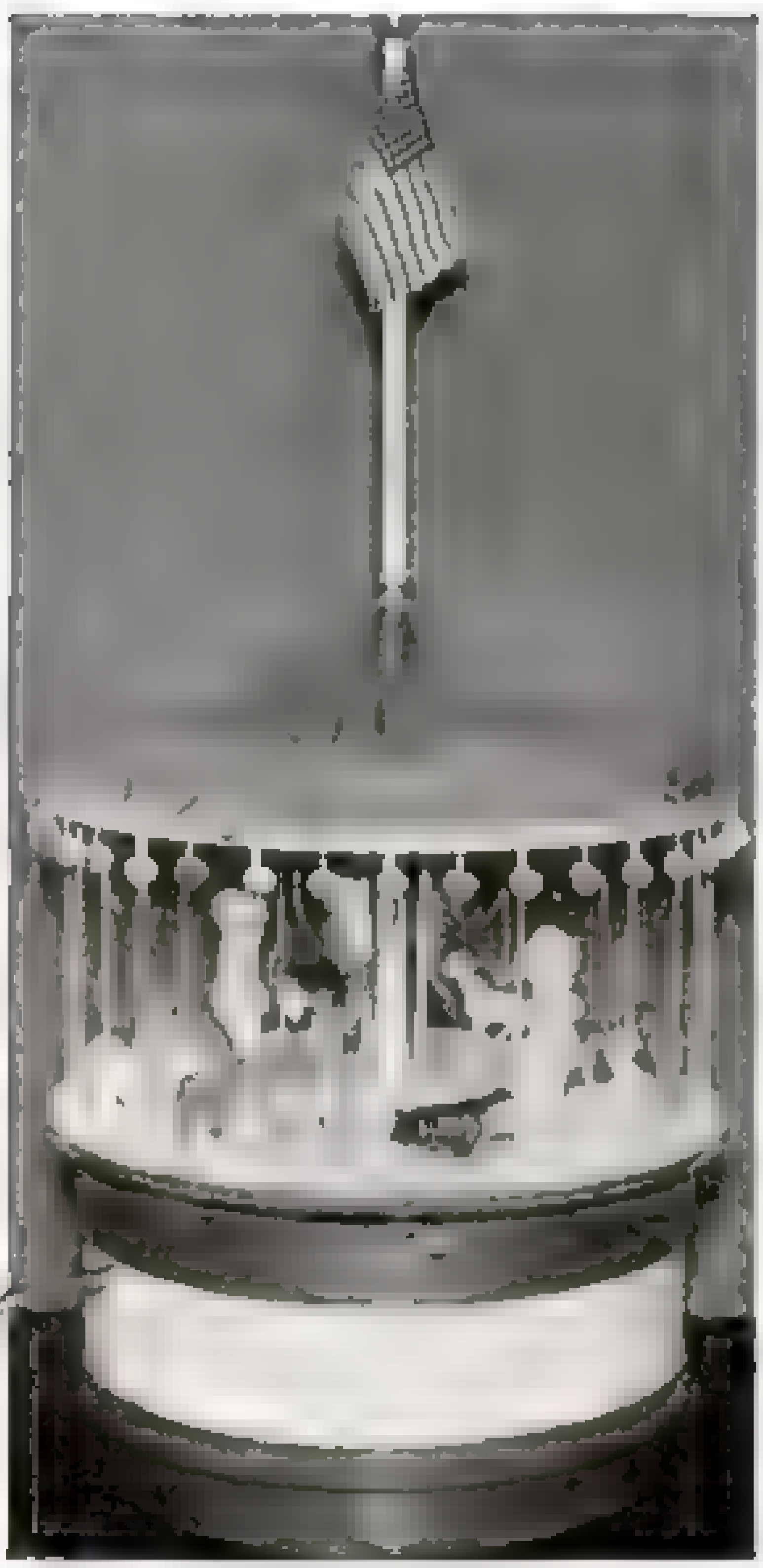
Hinges and a latch, or hasp and staple, should next be attached. It is advisable to put these on with small 3/16" carriage bolts and washers instead of wood screws, as the bolts will not pull out in rough usage. Note the somewhat unconventional way in which the strap hinges and hasp are placed. This is done in order to keep the top surface of the lid clear of hardware. A variety of handles can be purchased, and a pair of these should also be bolted to the ends.

The entire interior, including the underside of the lid, is painted French gray. Maple oil stain is applied to the outside of the chest and wiped off until the desired color is attained. The stain is then protected with several applications of white shellac.

The final step consists of cutting out the decorative metal corners. The writer obtained several 2-gal. auto-oil containers and used the metal from these. The child's initials, an anchor, a skull and bones, or some other suitable design can also be cut from the tin to ornament the front of the chest. All the metal decorations are drilled with 1/8" holes for screws and then painted flat black. The decorations were fastened to the chest with 3/8" No. 4 roundhead wood screws.

Toy Merry-Go-Round Built from Old Phonograph

By CARL F. WIEGMAN



ANY child's eyes will light when he's given this merry-go-round, but the real fun begins when it is set spinning and the music starts. If you have an old phonograph and some kind of musical toy on hand, the cost is very small.

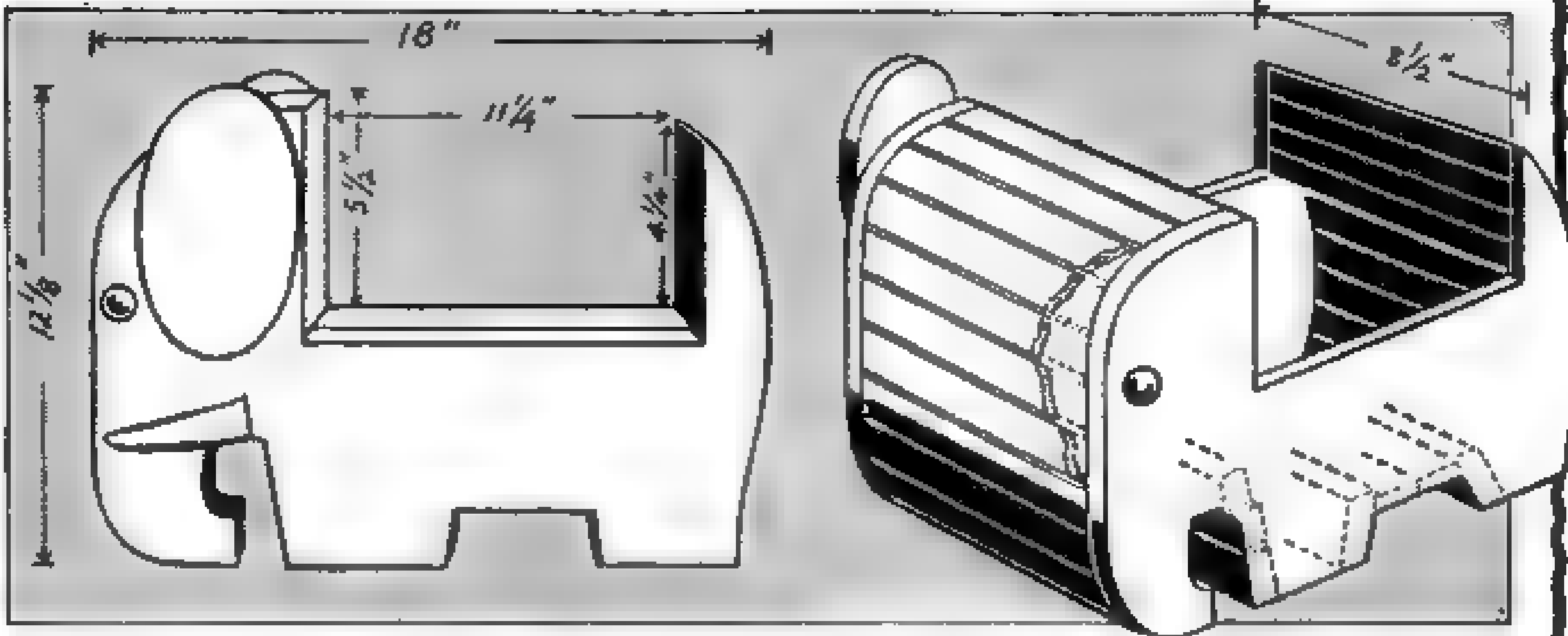
For the base, get a round cheese box from a dairy or grocery. Mount the spring phonograph motor on the underside of the lid with the shaft exactly in the center. The holes for the mounting screws can be located with the aid of a paper pattern. Fasten the musical toy inside to one wall, so that the winding key projects.

Cut two 18" disks from 3/4" plywood. In each drill 16 evenly spaced 5/32" holes 3/4" from the edge and 1/2" deep. With the holes aligned, clamp the disks together and drill three 1/4" holes near the center, spaced exactly like those in the mounting flange on the underside of the phonograph turntable. At the center, bore a 3/4" hole through the top disk and part way into the other.

Taper a 30" long dowel for about half its length and push it through the top disk. Fasten it to the bottom one with a single screw. Fit 16 pieces of No. 9 wire, 9" long, in the holes provided. Attach the mounting flange underneath and clamp the disks together with three 10" stove bolts and nuts.

The phonograph-needle container is cut out to fit over the center pole, and 16 small holes are drilled around it. From these, strings run to the outer edge of the top disk. Cement a piece of curtain fringe around this edge as trim. Tiny dolls, animals, and other toys can be fastened on with model-airplane cement after the merry-go-round is painted.

Tighten the motor governor to give a very low speed. Then, by moving the regular phonograph control lever from one side to the other, you will be able to start and stop the merry-go-round.



CHILD'S ELEPHANT CHAIR

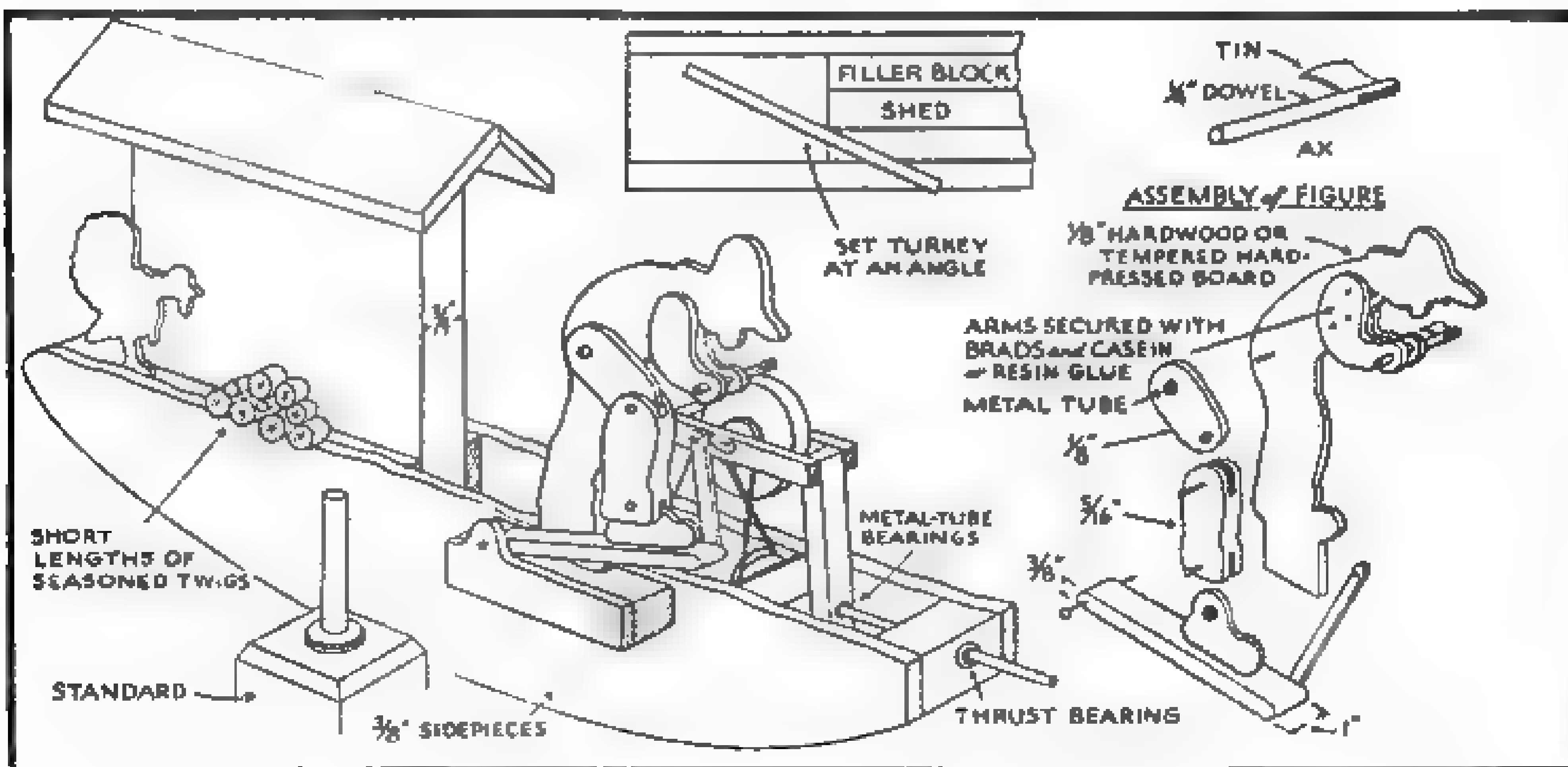
Designed by Juan Oliver

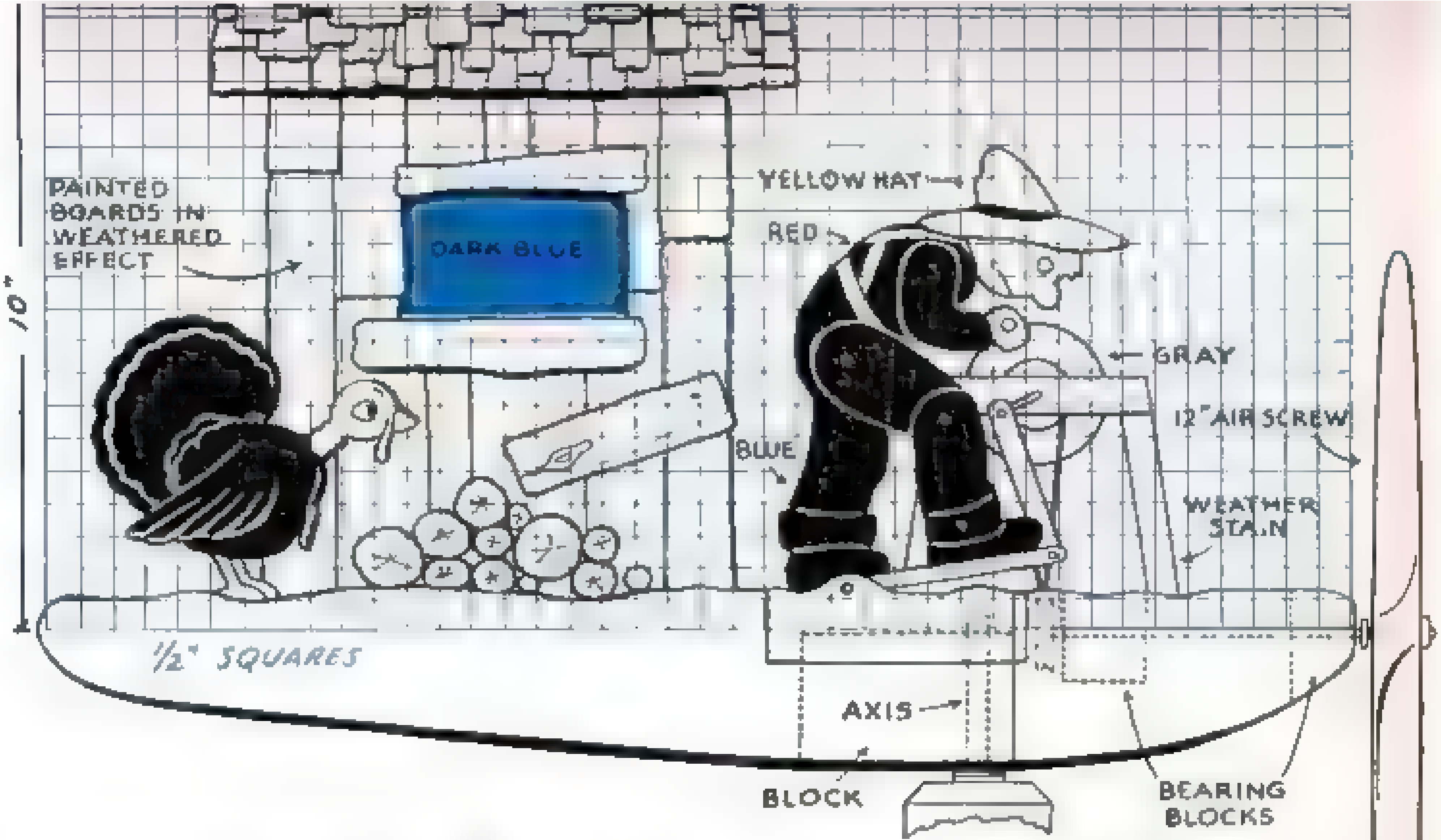
JUNIOR will be proud to occupy this "all-his-own" little chair while Mother reads to him, and in other moods will make adventurous journeys on elephant back.

Draw the side profile on paper or directly on ¾" plywood. Cut out two identical sides and join them with ¾" thick crosspieces. Plane or rip these at an angle as necessary to fit the contour. At outside curves, let the crosspieces project slightly and plane them down afterward to obtain a smooth surface for an over-all covering of oilcloth or other fabric.

Cut the cloth oversize to the approximate shape of the sides, and stretch it over them first, tacking it to the edges all around. Take a long strip 10½" wide, fold under 1" at each edge, and fasten one end with upholstery tacks inside the corner where the front edge of the seat board will go. Stretch the material over the head, down around the trunk, legs, and so forth, and finally up over the back and down again, tacking the end fast inside the corner at the back edge of the seat.

Saw tusks from ¼" plywood and tack them on. Ears are cut from waste ¾" stock and covered with the same or a contrasting fabric after they are nailed on. Attach a short strip of cloth as a tail. Large gilt tacks form the eyes. Fasten the seat board in place with nails sunk beneath the surface.



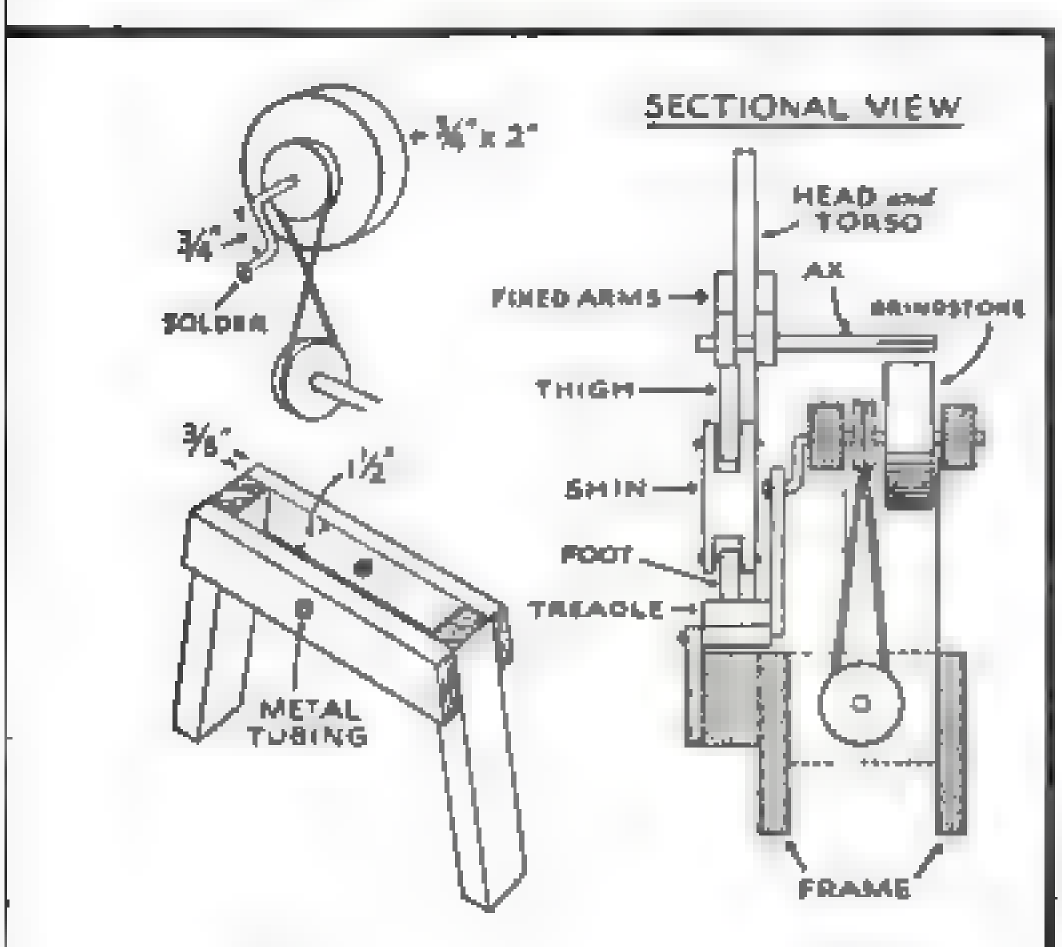


Ax-Grinder Windmill

By HI SIBLEY

IN THIS amusing animated windmill the gobbler peers apprehensively from behind the woodshed as the farmer, his back turned, grinds the ax for the execution. The mechanism is driven by a 12" air screw, and the speed of the grindstone can be adapted to local wind conditions simply by changing the size of the pulleys.

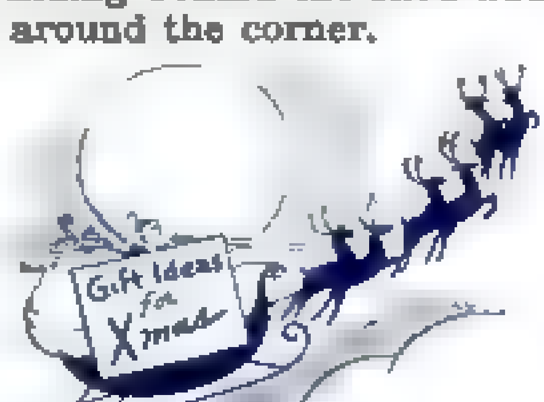
Mounted on a post, the frame consists of two side members between which are installed bearing blocks for the propeller shaft. Use short lengths of tubing, preferably brass if available, forced into holes drilled through the wood. A piece of tubing over the vertical axis is also recommended, and a small cast-off ball thrust bearing to carry the load, or at least two or three washers.



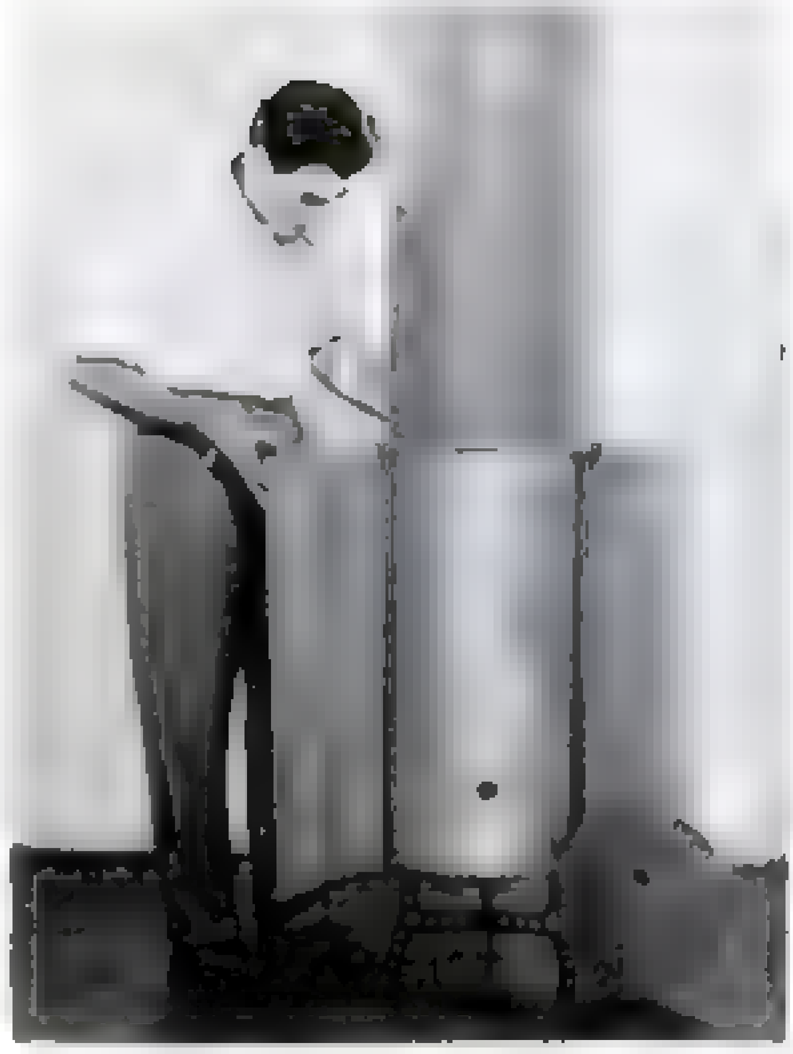
Tempered hard-pressed board 1/8" thick is ideal for the figure because it is waterproof. If none can be had locally, use hardwood of the same thickness and apply two coats of spar varnish over the color paint.

Note that the lower leg unit is of thicker material than thigh or foot, and is slotted to overcome wobble. Short pieces of small-diameter tubing set into the joints as shown will insure smooth action. Aluminum tubing such as used in the filters of many tobacco pipes is satisfactory, or the tubing supplied with various model airplane kits. Cut with a file to avoid crushing. Thin washers should also be used on each side of all bearings.

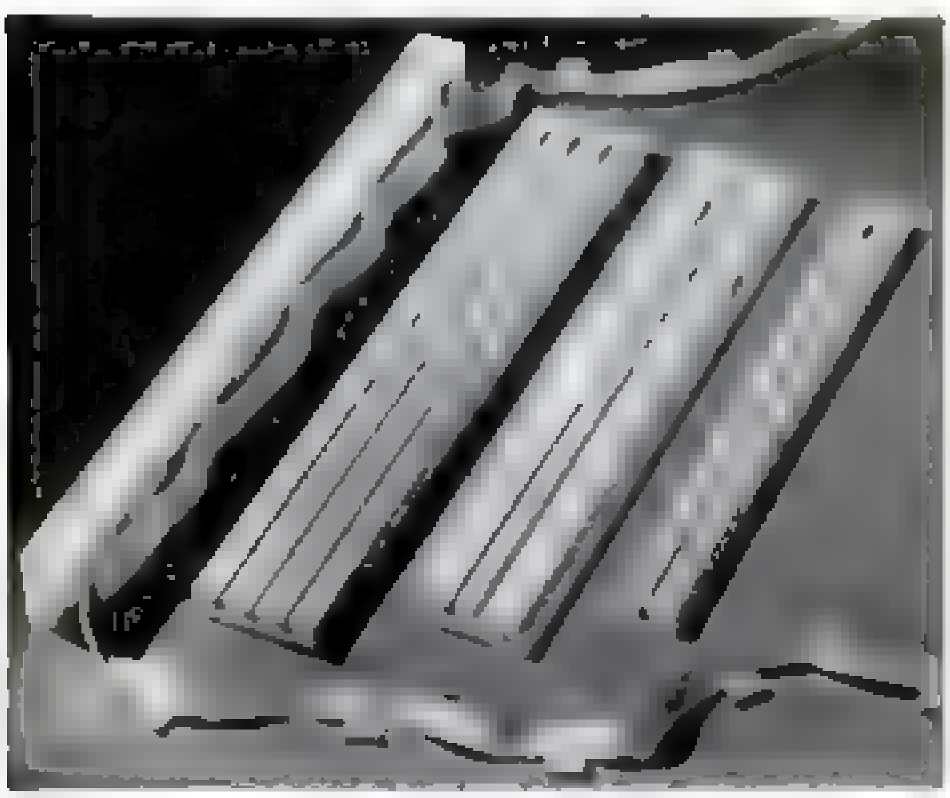
The woodshed serves as vane. Whittling irregular outlines will heighten the effect of a weather-beaten structure. Paint the whole appropriately. Cut short lengths of seasoned twigs and stack them against the shed, and secure the turkey at an angle so that it appears to be hiding behind the shed and craning its neck around the corner.



IDEAS for HOME OWNERS



JACKETS MADE OF CORRUGATED PAPER are on the market for insulating hot-water tanks as a step toward conserving fuel, increasing efficiency, and keeping rooms or basements cool. The jackets are of five-ply material enclosing air spaces, and are designed to cover either 30-gal. or 40-gal. tanks. They are available in wood-grain, gray, and green finishes, effective in modernizing the appearance of old-fashioned tanks in basements that are to be done over as basement play rooms or in kitchens or bathrooms. The jackets are put on the tanks in sections, as shown at the right, and the joints sealed with matching tape.



CURTAIN HANGERS OF WOOD, used as a substitute for metal curtain rods, have been introduced in four styles that permit a variety of treatments of drapes, from simple glass curtains to complicated cornice or concealed blackout arrangements. These hangers are in reality wooden moldings containing one, two, or three slots, as shown at left. They are used with special sliders that fit in the slots and move easily along as the curtains are drawn. The sliders may be sewn individually to the top edge of the curtains, or they can be obtained on tape that is sewn on in one piece. Moldings may be nailed to the window head trim or, in the case of new work or a complete remodeling job, recessed in the wall plaster.

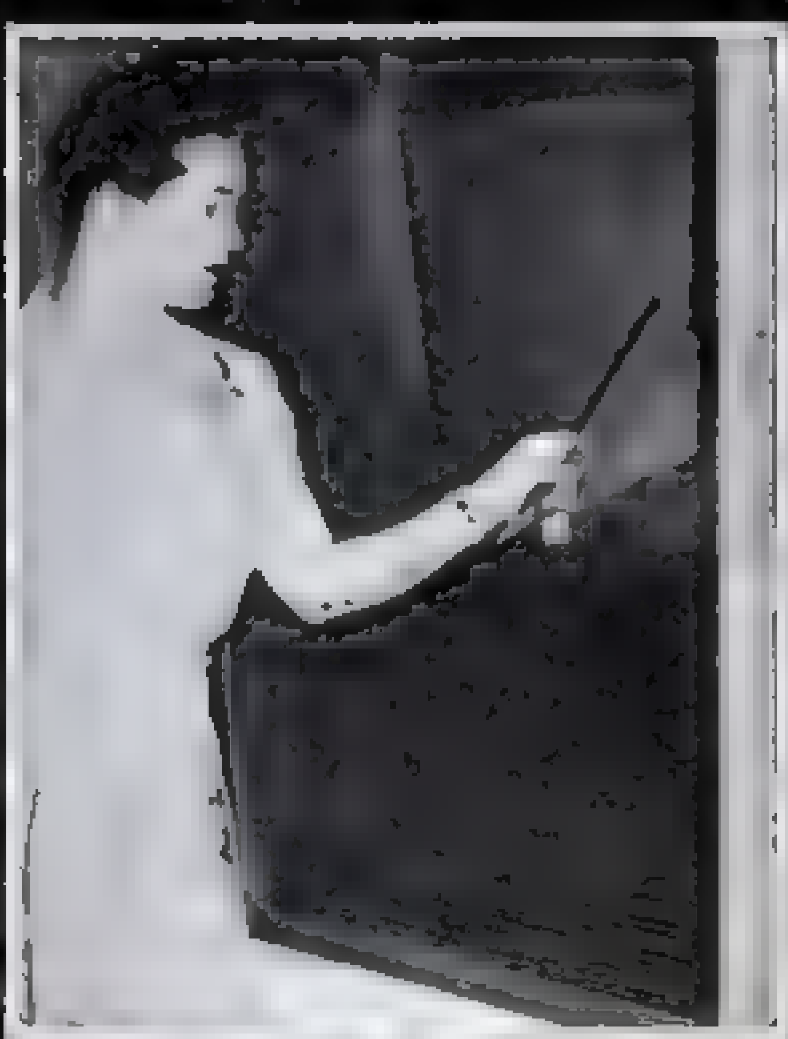
PAINTBRUSH PROTECTION may be increased now with the use of a metal case that saves the bristles when the brush is stored, even for long periods at a time. Ordinary precautions in thoroughly cleaning used brushes are necessary before storing, but after that the container will keep the bristles from "puffing up" or otherwise losing their shape, such as frequently happens when paintbrushes are not put into service for several months. The case is hinged at one end, open at the other, and snaps shut over the brush, acting as a complete cover for the bristles and the rubber or composition "set." Cases are available in several standard sizes ranging from 2½" to 5".

PLASTIC SCREW HOLDERS for use with marble, concrete, metal, and mortar joints, as well as with wood, tile, brick, and plaster, can be obtained in powder form. A pinch of the powder is rolled between finger and thumb, moistened to make a plastic plug, and inserted to fill a hole drilled to receive a screw or nail, which is then driven in tightly. Pressure applied during the driving expands the plastic and anchors it to the sides of the hole. Screws fastened in this way may be removed and replaced.

BLACKOUT ACCESSORIES FOR THE HOME

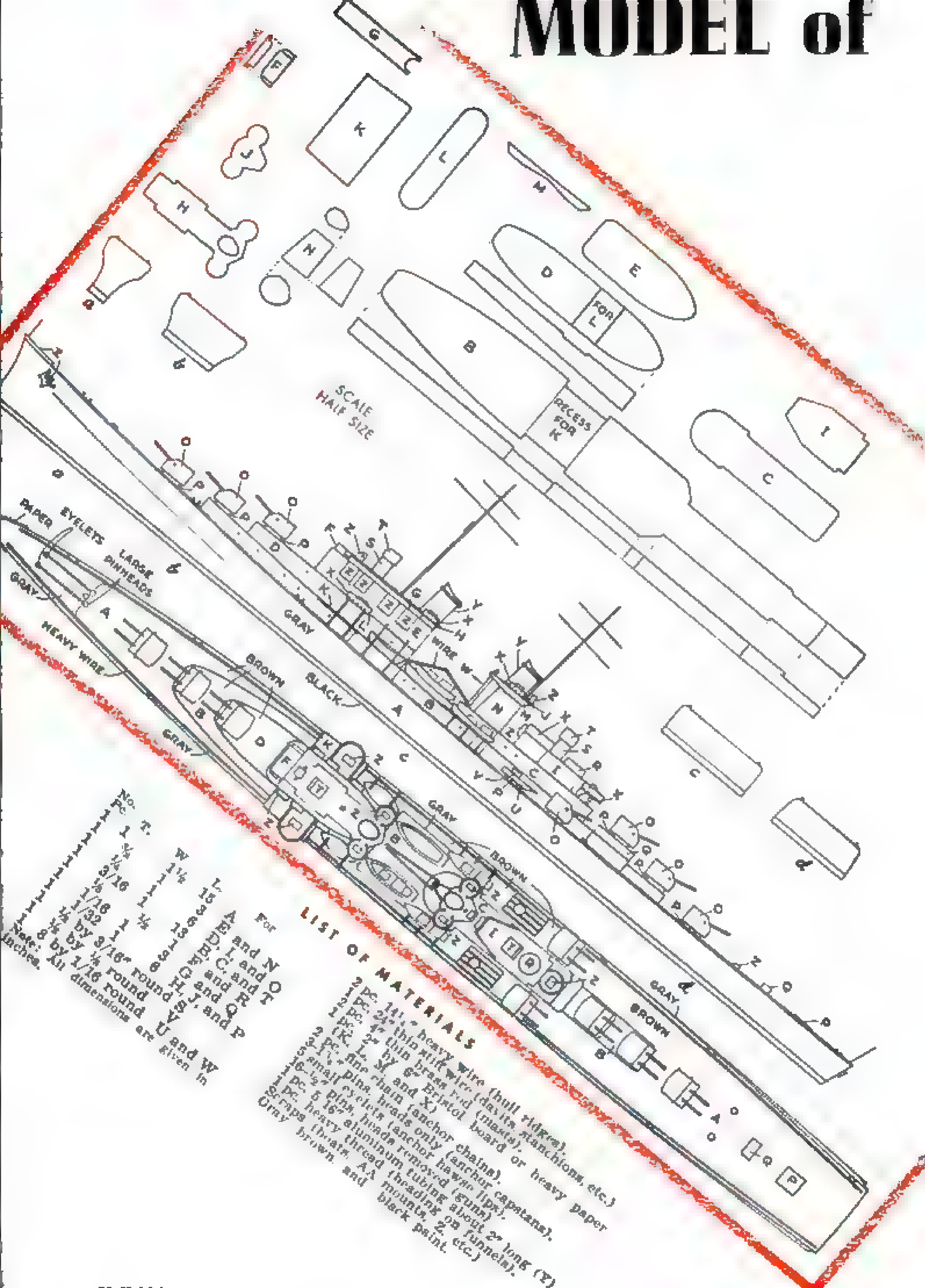
SAFE LIGHT DURING BLACKOUTS is provided by a small bulb that fits standard sockets. It is opaque all over except for a circular area on one side. With this turned away from windows, the lamp may be left on during blackouts even though the shades are up.

A NEW DIMOUT SHADE that fits most table, floor, and wall lamps is equipped with its own 7½-watt bulb. The opaque hood directs all illumination downwards, and can be raised or lowered on its holder to enlarge or diminish the cone of light. It is made easy to find in total darkness by a luminous "V" on the shade. Similar in design is a dimout lamp that can be used anywhere independently of electric service lines. It is equipped with a bulb powered by two standard flashlight cells. Rotating the shade turns the light on or off. A luminous letter on the shade enables householders to locate the lamp readily even if ordinary illumination suddenly fails.



VENTILATION IN A BLACKOUT ROOM is no longer impossible, thanks to a new type of shade that fits standard windows up to 42" in width. One part of the unit is a wooden frame in which are set inverted, V-shaped louvers of black cardboard that allow air but not light to pass through. This is placed in the lower part of the window. The upper part is covered with opaque fabric tacked to a roller or to the window frame.

MODEL of



No. Pc.	T.	W.	L.	For
1	1	1¼	15	A and N
1	¼	1	3	E, I, and O
1	3/16	1	3	D, C, and T
1	⅛	1	6	B, F, and R
1	1/16	1½	6	G and Q
1	1/32		13	H, J, and P
1		1	6	K, V, S
1	⅛ by 9/16" round			U and W
1	¼ by ¼ round			
1	8 by 1/16 round			

Note: All dimensions are given in inches.

LIST OF MATERIALS

2 pc. 14½" heavy wire (hull ridges).
1 pc. 24" thin stiff wire (davits, stanchions, etc.)
1 pc. 4" thin brass rod (masts).
1 pc. 2" by 6" Bristol board or heavy paper (K, L, M, and X).
2 pc. 1½" fine chain (anchor chains).
2 1½" pins, heads only (anchor capstans).
2 small eyelets (anchor hawse lips).
18 ½" pins, heads removed (guns).
1 pc. 5/16" aluminum tubing about 2" long (Y).
1 pc. heavy thread (beading on funnels).
Scraps (boats, AA mounts, Z, etc.)
Gray, brown, and black paint.

the New Light Cruiser U. S. S. *ATLANTA*

By THEODORE GOMMI

AMONG the most interesting recent additions to the U. S. Navy are the 6,000-ton light cruisers of the *Atlanta* class. Triple-tiered turrets, streamlined superstructures, and well-sheered hulls give them a distinctive appearance that bespeaks the 40-knot pace at which they can travel. Eight vessels are in this class. They have numerous dual-purpose 5" guns that give antiaircraft protection to other ships. Since detailed plans are secret, our model is based on photographs released by the Navy, and of necessity is a water-line model.

Finish the hull *(A)* before starting the superstructure. Because of the extreme sheer of the main deck, the housing *(B)* takes a similar sheer. Bridge decks, however, are level, the adjustment being made by a wedge-shaped piece *(D)*, the undersurface of which must be carefully fitted to *B* after *B* is mounted on *A*. In shaping *A* (after trimming to a blank with the contour shown in the plans), note the unusual forecastle. The bow flare stops short about one deck level below the main deck, forming a noticeable ridge.

The stern has a slight "tumble home" that starts aft of the beam turrets and increases gradually. The edge of the main deck is rounded for almost its entire length. There is a ridge where the edge flattens into the deck. This is shown by a length of wire bent to contour and glued into place. The ridge passes inside the bitts, davits, and stanchions.

Bitts are short pieces of wire inserted in pairs. Anchors may be cut from heavy paper or celluloid and glued on. Dime-store jewelry provides anchor chains.

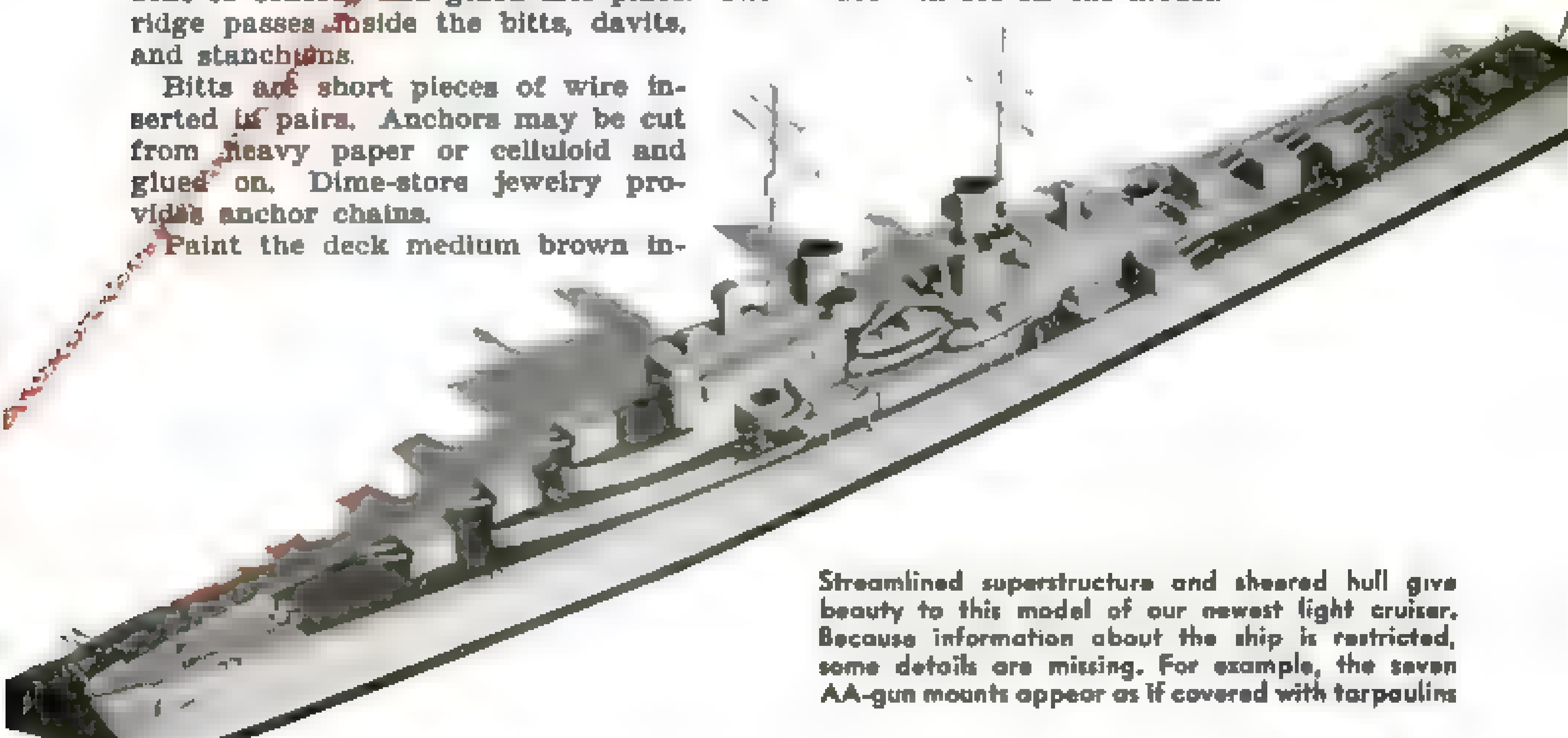
Paint the deck medium brown inside the ridge from bow capstans to stern. The rest of the hull is gray except for a ⅛" black strip at the water line.

Shape *B*, and glue *K* into the recess provided. Drill portholes. Paint the sides gray. This deck is brown to the aft of *K*, and then gray. Glue *B* to *A*, and hold in a vise, if available, until dry.

Proceed with the remainder of the superstructure, turrets, torpedo tubes, boats, and the like, following the plans. The forefunnel passes through platform *H* and fastens to *E*, whereas the second funnel is glued to platform *J*. Covering *M* with transparent cellulose tape prevents tearing. Thin strips of heavy paper protect the seven AA-gun platforms. "Pockets" on the sides of *E* are thin pieces of wood. The front edge of *N* must form a continuous straight line with the front of the second funnel. Beading on the funnels is heavy thread held with glue.

Torpedo tubes are four pieces of 1/16" dowel glued to a base and capped with a disk of ⅛" dowel. Cubes of wood, with upper edges slightly rounded, give the effect of the seven AA-gun mounts covered with tarpaulin. Masts are brass rod, filed to taper slightly, with crosstrees of thin wire carefully balanced and held with a drop of glue.

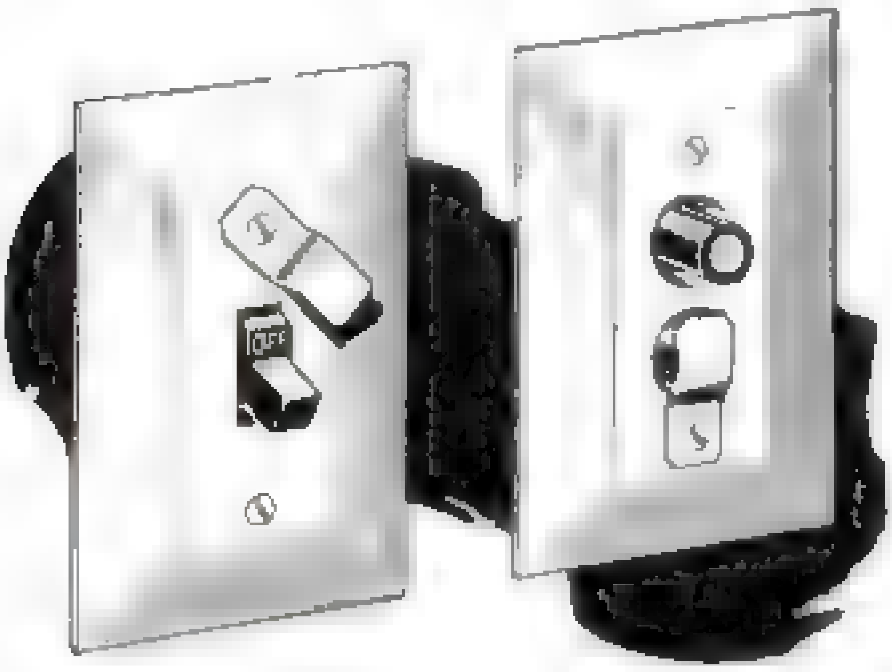
All these parts are painted gray (except the exposed deck of *D*, which is brown) and then fastened to *A* and *B*. Edges of funnels, AA mounts, and undersides of boats are then touched in black. A polished wood base will set off the model.



Streamlined superstructure and sheered hull give beauty to this model of our newest light cruiser. Because information about the ship is restricted, some details are missing. For example, the seven AA-gun mounts appear as if covered with tarpaulins

Clips Fastened to Switches Are a Safeguard During Blackouts

CHILDREN and absent-minded grown-ups won't be able to turn on lights during a blackout if wall switches are fitted with simple clips as shown in the drawings below. These will also prevent young children from switching on lights during the daytime, when they may not be noticed, and they may prove to be a valuable safety device in a photographic darkroom, where they may save film and paper from being light struck. The clips work equally well on toggle or push-button switches, and do not interfere with normal use.



Eight clips can be cut from a 5/8" by 12" scrap strip of 28-gauge galvanized iron or other suitable material. Make them 1½" long, clip off the corners, and file smooth any sharp edges. With a center punch, make a hole in each 5/16" from one end large enough to admit one of the screws holding the switch plate.

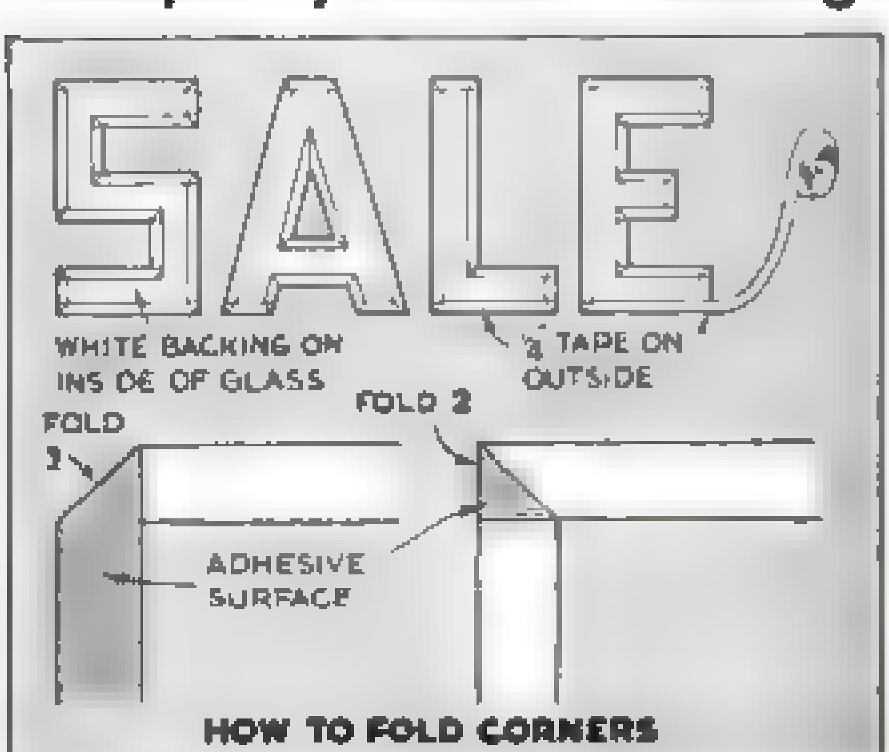
Bend a suitable offset in the clip and mount it, turning the screw up fairly tight. If desired, the clips can be gilded or finished in some other fashion so as to be less conspicuous.—WALTER S. MACLELLAND, JR.

Wooden Treads Replace Tires on Tractors and Combines

A PARTIAL solution of the tire problem has been worked out for Kansas wheat farmers by OPA rationing experts. The OPA office in Wichita had a trial set of wooden lugs built of 3" by 6" white oak and attached to the rims of tractor wheels with 3/8" to 5/8" iron rods, which were clamped around the wheels with turnbuckles. The lugs are applied at an angle of 35 to 40 deg across the rim, 15 to each wheel, and are 18" to 24" in length, depending on the width of the tractor rim. In tests, these treads were found to give the required traction. The cost of equipping two wheels runs from $35 to $50.—HOWARD R. MARSHALL.

Oak lugs clamped to rim of a tractor wheel

Temporary Window Lettering Done Neatly with Colored Tape

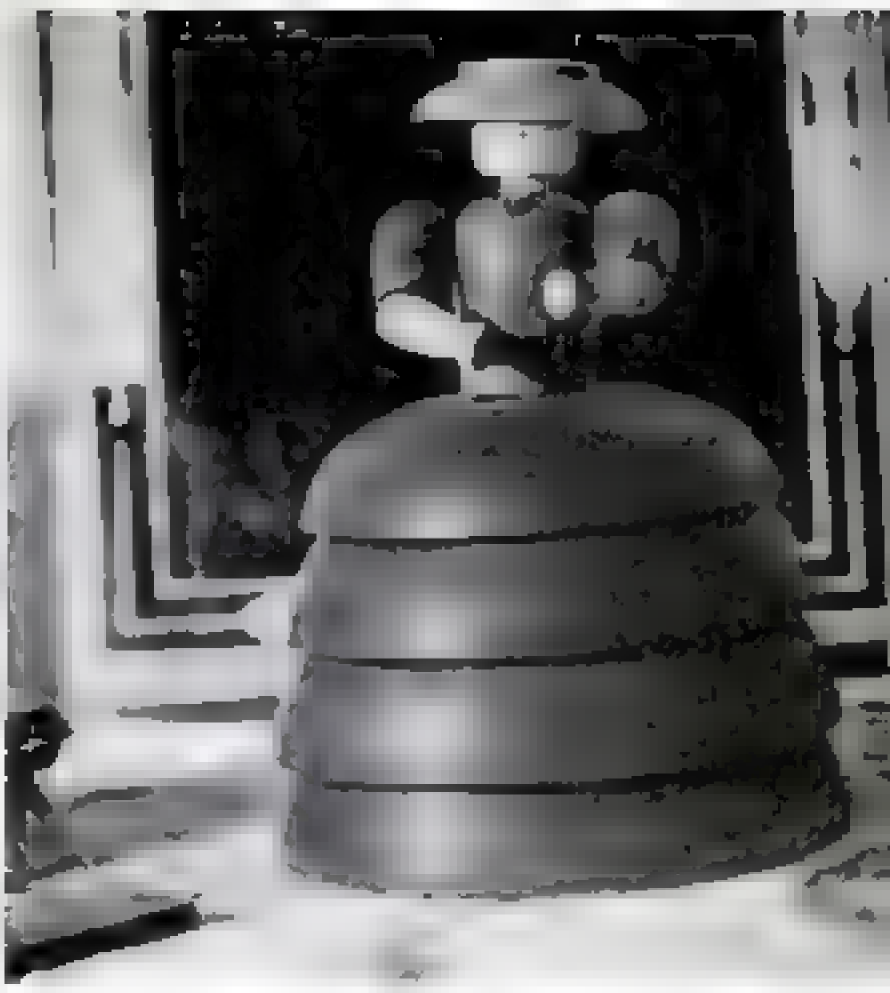


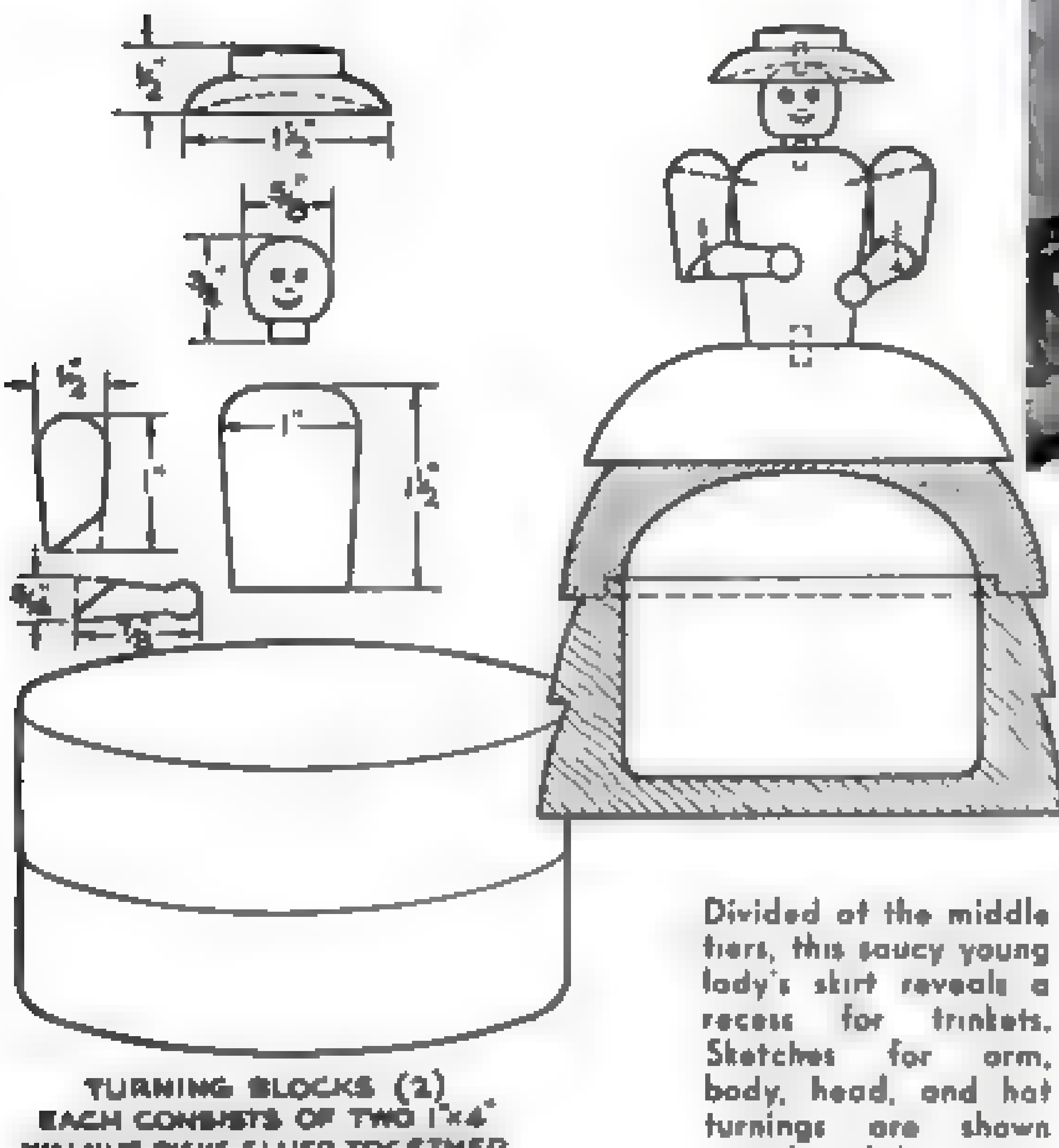
COLORED cellulose tape ¼" wide may be used to make neat temporary window signs that vie with professional jobs if sufficient care is taken in laying them out. One type of lettering is shown in the drawings at the left. Letters can be laid out with a ruler and chalk, or by snapping a chalk line.

Contrast is gained by the use of a white background, which may be a powder-type window cleaner applied in an even coating to the inside of the glass after the tape outline has been put on the outside. Both the tape and the background can be removed quickly, leaving the window perfectly clean.—FRANK SHORE.

Polly Pert

A JEWEL BOX FOR A GIRL'S TABLE





Divided at the middle tiers, this saucy young lady's skirt reveals a recess for trinkets. Sketches for arm, body, head, and hat turnings are shown at the left above

A NOVEL dresser box is this pert little lady with leg-o'-mutton sleeves and tiered skirt, within which is room for powder, trinkets, or what milady's fancy dictates. The body of the original was turned from black walnut, head and arms from maple, but you can use any type of wood that harmonizes with your furnishings.

For the skirt, glue up two turning blocks from four 4" disks of 1" thick wood. Mount both on waste wood before screwing them to the faceplate. The flounces in the skirt conceal the joint of the box.

Sleeve and arm turnings are cut at a slant where they meet at the elbow. Fasten them with glue and brads. A small nail driven into the body through a hole in each arm allows the arms to be raised. All other parts are doweled and glued. Paint in features and finish with wax.—E. W.

An Edible Santa Claus Favor for the Christmas Table

THIS decorative Santa Claus favor is 90 percent edible. It will delight the children at a Christmas party and amuse the grown-ups. Santa has a shiny red apple for his round body. Raisins pushed over toothpicks serve as arms and legs. The mittens are red cranberries; the shoes, meats from pecan nuts cracked carefully so that the halves will come out whole. A marshmallow head is studded with three cloves for the eyes and nose, and mounted on the body with a toothpick. Absorbent cotton forms Santa's snowy beard, and a bit of pipe cleaner his mustache. Add a pointed red gumdrop hat and another pipe cleaner as fur trim on his jacket.—B. N.

Benchwork

Paring a concave curve. The chisel bevel is down, and the tool can be rocked on it for perfect control of the edge

By EDWIN M. LOVE

ALTHOUGH machines have greatly speeded up the more tedious operations of woodworking, much of the finest cabinetwork requires careful hand fitting, and master craftsmen are rightly proud of their skill in using bench tools. Often, too, the shape of work or its size makes it impossible to do a certain operation on home workshop machines. In such cases, the job must be done by hand. Two classes of tools that every woodworker should be familiar with for this and other reasons are chisels and boring bits.

A chisel is a most adaptable and versatile hand tool. With it alone, skilled hands can shape all kinds of wooden objects, requiring neither a saw to cut the piece nor a plane to smooth it. Boring bits also are vital tools. A brief study of chisels and boring kits, and a little practice, will enable the beginner to do better handwork.

What chisels should be purchased for the home workshop? Buy the various sizes as needed. Since they will be used not only for light work, but also in making heavy pieces such as garden pergolas and seats, chisels with handles set into sockets are better than those with tangs. A long ¼" chisel is useful for most narrow work; a ¾" chisel is handy for cutting dadoes; and a wider one, such as a 1¾" butt chisel (much favored by carpenters for dapping in door hinges) has many uses in the home shop.

How is a curve pared? On thin stock, the curved end of a board should be cut within 1/16" of the line with a coping or turning saw. Clamp the work in a vise, and if the curve is concave, place the bevel of the chisel against the wood. When the nature of the work permits, grip the blade firmly with the left hand; otherwise, hook the thumb and forefinger over the top of it as shown in the photo at the left, while the right hand on the handle supplies pressure. Rock the chisel back on the bevel as cutting proceeds—a means of exerting delicate control. On convex curves, pare with the bevel up. If a wide chisel is used, swing it sidewise in a shearing cut. Rough-cut wide stock with a saw and drive the chisel with a mallet, or with the side of a hammer head, as carpenters do, taking care not to tear the fibers deeply. It is advisable to make successive narrow cuts from edge to edge, as in Fig. 1, afterwards shearing across the edge. Heavy pieces can also be trimmed with shearing cuts from the side while clamped to the bench, as in Fig. 2.

Can chamfers be made with a chisel? Yes. Lay out the chamfer with a pencil, not a marking gauge or point, and trim with the grain, the bevel of the chisel down, as in one of the accompanying photographs. Finish straight with a plane. When chamfering end grain, cut on the bias with a shearing motion, and work from both edges to prevent splitting, unless the edges already are chamfered. Work a stop chamfer from both ends and then with the grain, finishing the center with a plane if possible. Stop chamfers on the end of a piece are chiseled from the center toward the ends, as illustrated in Fig. 3.

What is the right way to cut dadoes? Saw the sides of the dado and bevel the

with Chisels and Boring Bits

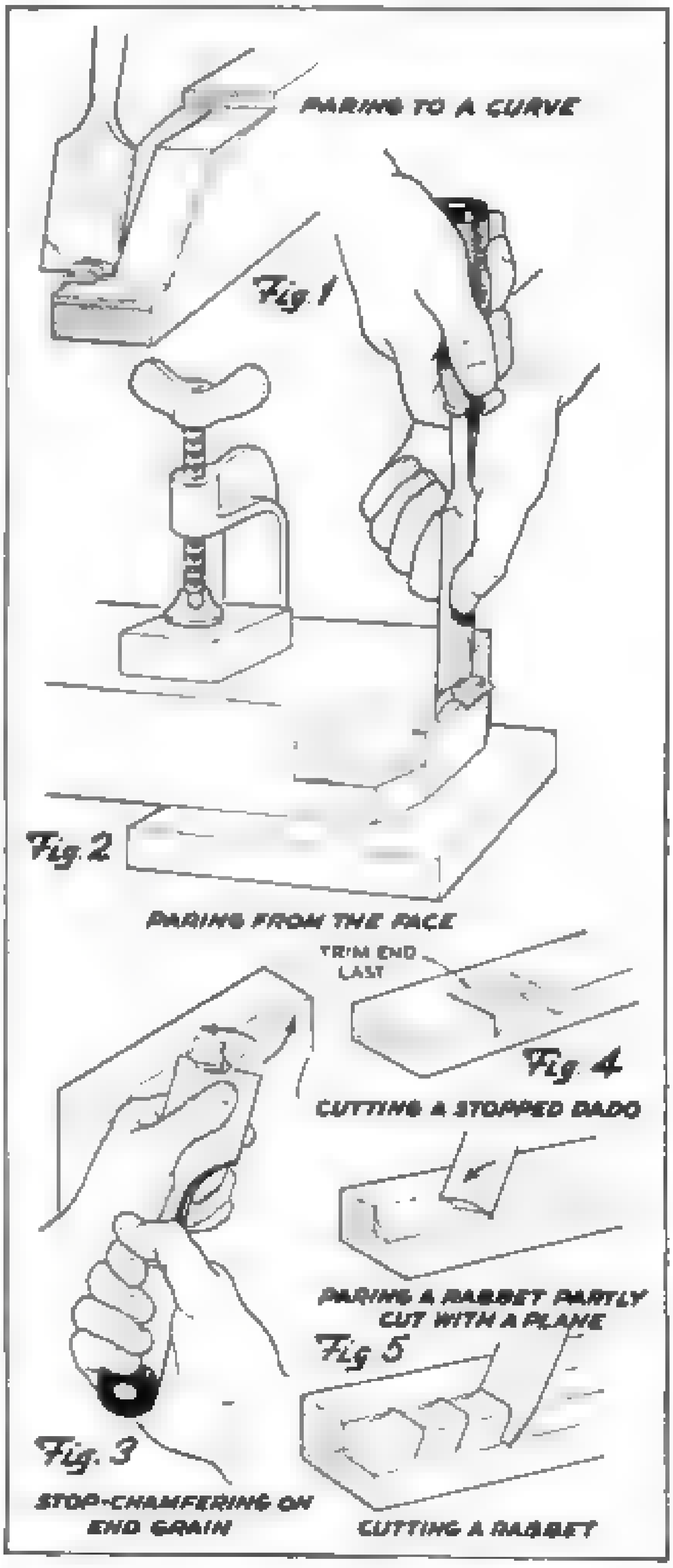
waste stock toward the kerfs at both sides, the flat side of the chisel down, as shown in the photograph on the next page. Work from both edges of the piece, unless the dado does not extend the full width, in which case make a chisel cut across it 1/16" inside the stop line, and work to it (Fig. 4). Lastly, trim this end to the line.

How is a rabbet cut? Gauge for width and depth and make successive cuts the length of the rabbet, hitting the chisel with the hand or a mallet. Trim the bottom and sides with shearing cuts. Sometimes a rabbet plane persists in veering off, and the cut may require paring with a chisel as shown in Fig. 5, before the plane can be used again.

What method is used for mortising in hinges? Hinges, drawer locks, and the like, are mortised much in the same way, by laying out, cutting inside the end lines, chipping, and trimming. Do not make cuts exactly at the end lines to begin with, as the fibers will be crushed and the edges will be unsightly. A hinge mortise and a typical lock mortise are shown in Fig. 6.

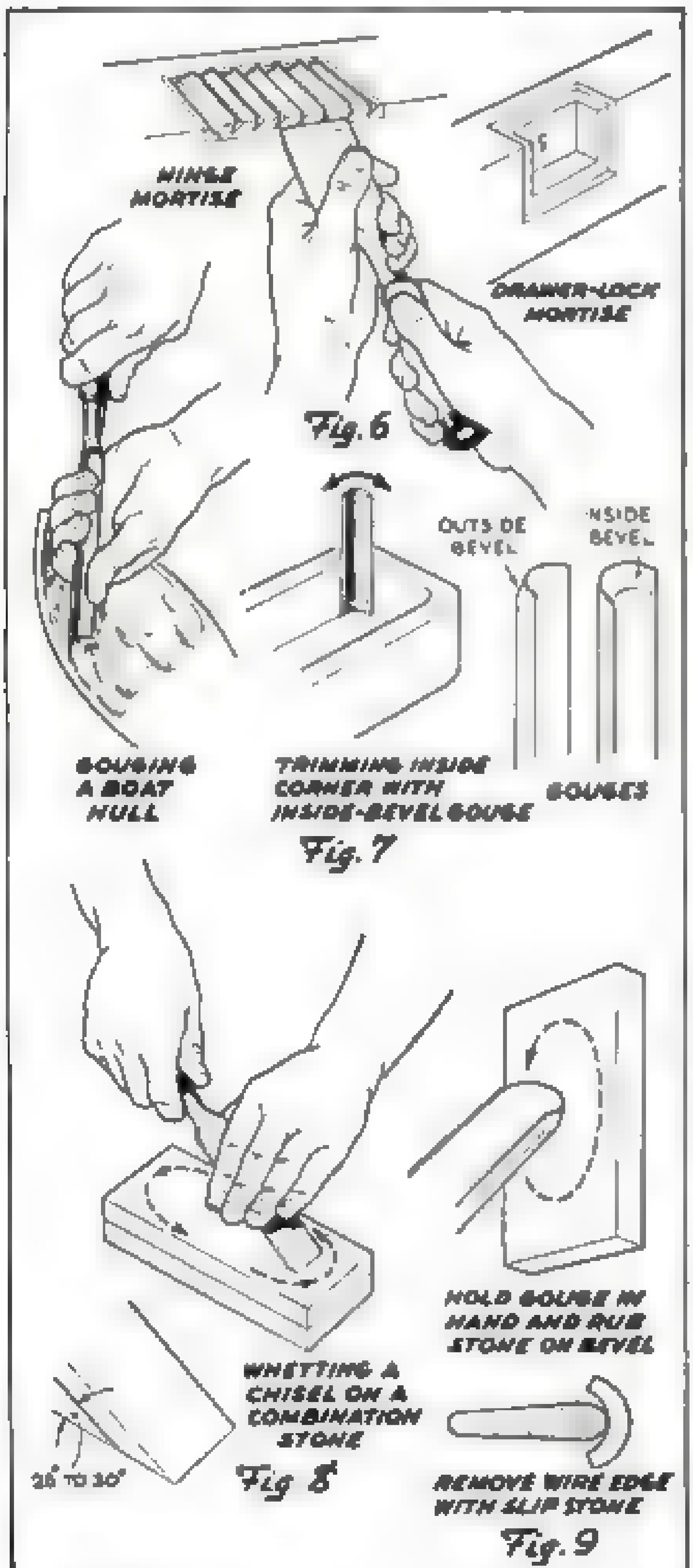
How are gouges used? Inside-bevel gouges are most useful. They are handled much like flat chisels in hollowing out work clamped to the bench, as in Fig. 7. Pare from the ends, working with the grain, and rock the gouge sidewise when cutting across

In making a stopped chamfer with a chisel, cut the two ends first. Hold the tool with the bevel down



the grain. The outside-bevel gouge is handy for rounding the outside corners of a box and other work for which the inside-bevel gouge is not adapted.

What is the best way to sharpen a chisel? Grind the bevel flat or slightly hollow, and square with the edges of the blade. Be careful to retain this shape in whetting. Sharpen it first on the coarse side of a combination stone, taking long, oval strokes (Fig. 8). Use light oil or kerosene on the stone to help cool the edge and to float away the bits of steel. When a slight wire edge turns up, wipe the stone and blade clean and rub the chisel, flat side down, on the fine side of the abrasive. Hone the bevel edge again on this fine side. Touching up on a razor hone, and stropping on a piece of leather belting, improves the edge. Gouges are sharpened as in Fig. 9.



How is an auger bit used? Hold the work in a vise, or with a clamp or the knee, and bore vertically or horizontally, as required. Check the angle with a try or bevel square. If the bit is sharp and the screw point good, it is self-feeding, and little pressure is needed. When the point pricks through, it stops feeding, and the hole should be bored through from the other side to prevent splitting. A block clamped to the back of the work will, however, permit boring right through from one side without splintering the back. If a backing block is not used, it is well to feel for the point with the fingers when the hole is nearly bored through. Holes can be bored to a required depth by using a bit gauge (Fig. 10) or putting a block of wood with a hole bored through it, or a piece of garden hose, on the bit. Figure 10 also shows other boring accessories and their uses.

What is the way to bore dowel holes? These require great accuracy, especially in frames. It is worth while to make a boring jig, or to purchase a metal one. Bore dowel holes 1/16" deeper than the dowel requires, to provide room for imprisoned glue, which otherwise might hold the joint open or split the wood.

Holes that must be bored at an angle, such as those for spreading bench legs and the like, can be made by aligning the bit with a bevel square set to the required angle. A better way is to bore a hole through a thick piece of waste lumber at the proper slant and clamp this piece to the work as a boring jig.

If part of the waste wood is removed from a dado with bevel cuts sloping toward both kerfs, deep splintering of the bottom of the gain is avoided

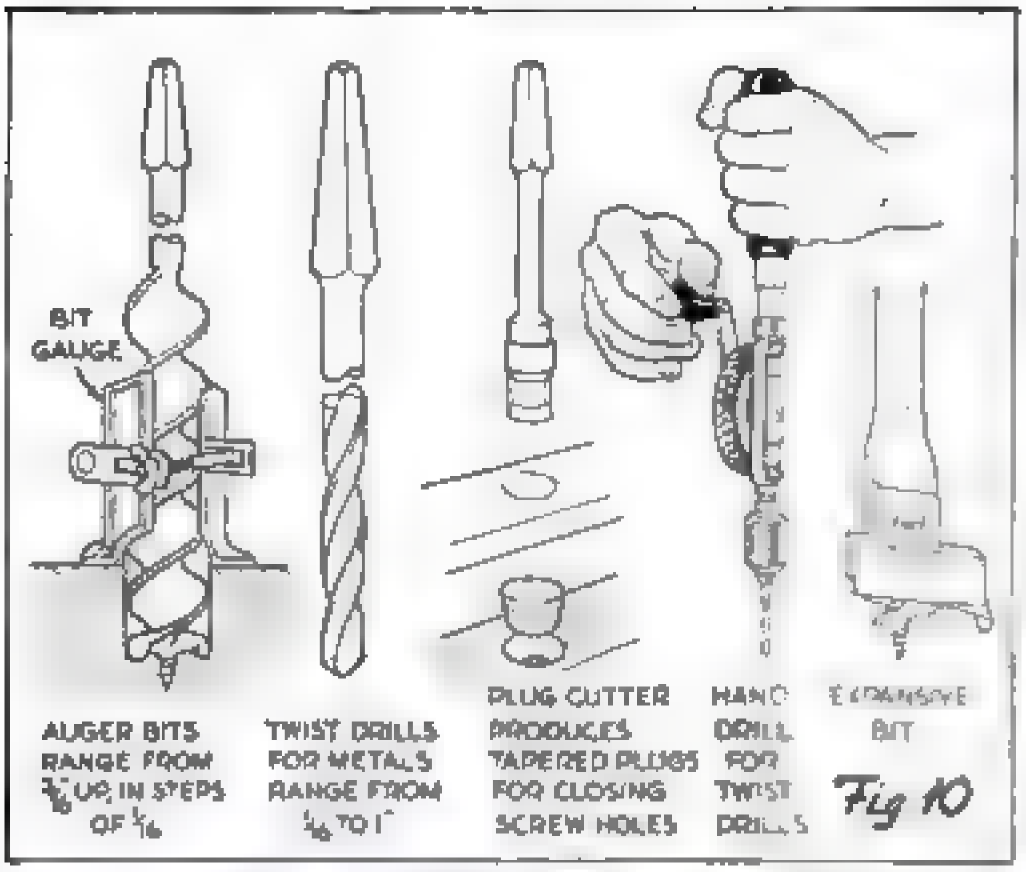


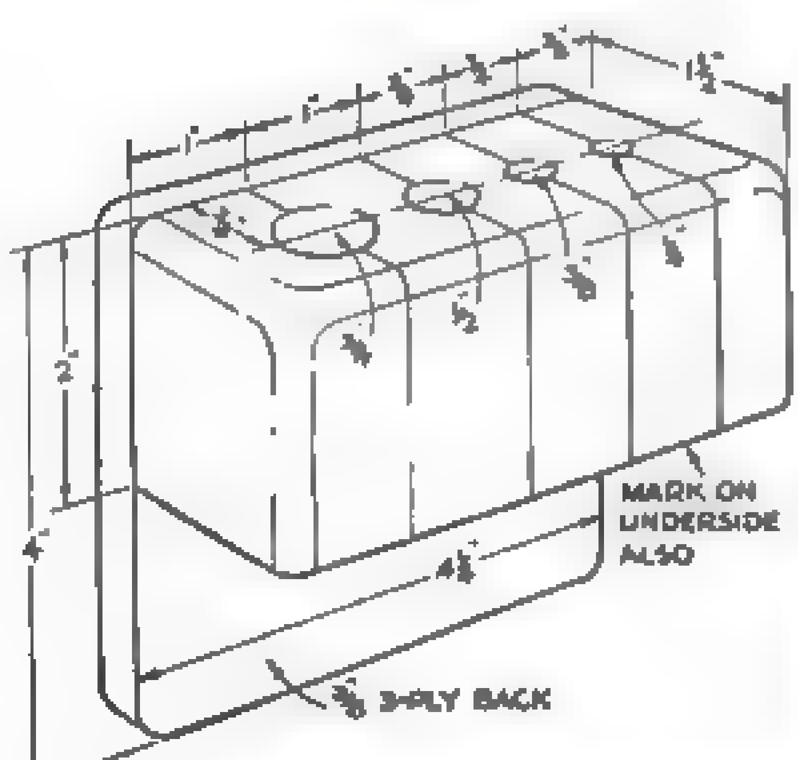
Fig 10

Automatic push drills are convenient for making small holes with one hand, as in drilling the spinning-wheel spindle above

In boring a hole completely through, feel for the point of the bit to prick through the back. When it does so, turn the work and finish boring from this side to avoid splintering

DOWELING JIG

[WOODWORKING]



Dowel holes may be bored easily and accurately with this simple jig. It consists of a hardwood block bored with four sizes of guide holes and screwed to a plywood back. In use, the guide is clamped to the work with the back against the face side. The jig can be used for boring dowel holes in the edges and ends of stiles and rails ranging in thickness from ½" to 1½". The guide holes are centered by inserting shims between the back and the work.

To make the jig, square up the guide block and score center lines around it. Bore the holes halfway through from each side to assure accuracy, and round the outer edges by chamfering them. The center lines of the holes are aligned with layout lines on the work. Make a set of wooden shims 3/16", ¼", ⅜" and ½" thick to be used with the jig.

POPULAR SCIENCE MONTHLY SHOP DATA

Fig. 1. You can work on square-knot belts at odd moments almost anywhere. The materials are easy to get and take little room. A knotting hook attached at the waist keeps the "filler" cords taut

Square-Knot Belts

Fig. 2. Square knots are made over the taut cords with two others. There are two separate hitches to each knot. Note how the black cord goes under the filler cords in both, the white cord over them

A FAVORITE TYPE OF NAVY CRAFTWORK THAT HAS WIDE APPEAL FOR SERVICE MEN

CRAFTWORK for men in service is something of a problem, but there is one time-honored type of work that can be practiced anywhere on short notice and without special equipment — making square-knot belts. The materials are inexpensive, and the product is durable, attractive, and varied in design.

Select the buckle first so that the belt can be made the required width. Belts for men usually are made of heavy, stiff cord; those for women of silk, linen, or cotton cord.

Multiply the length of the belt wanted by eight, and cut strands of cord to that length —ten strands will make a belt about 1¼" wide. Double each in the middle to form twice as many working cords.

Start by looping two double strands over two push pins placed close together in a wall, table edge, or chair. Hold the two inside "filler" cords taut with a knotting hook attached to your waist (Fig. 1). Over these make a square knot with the two outside cords as is being done in Fig. 2.

Note that there are two distinct hitches to

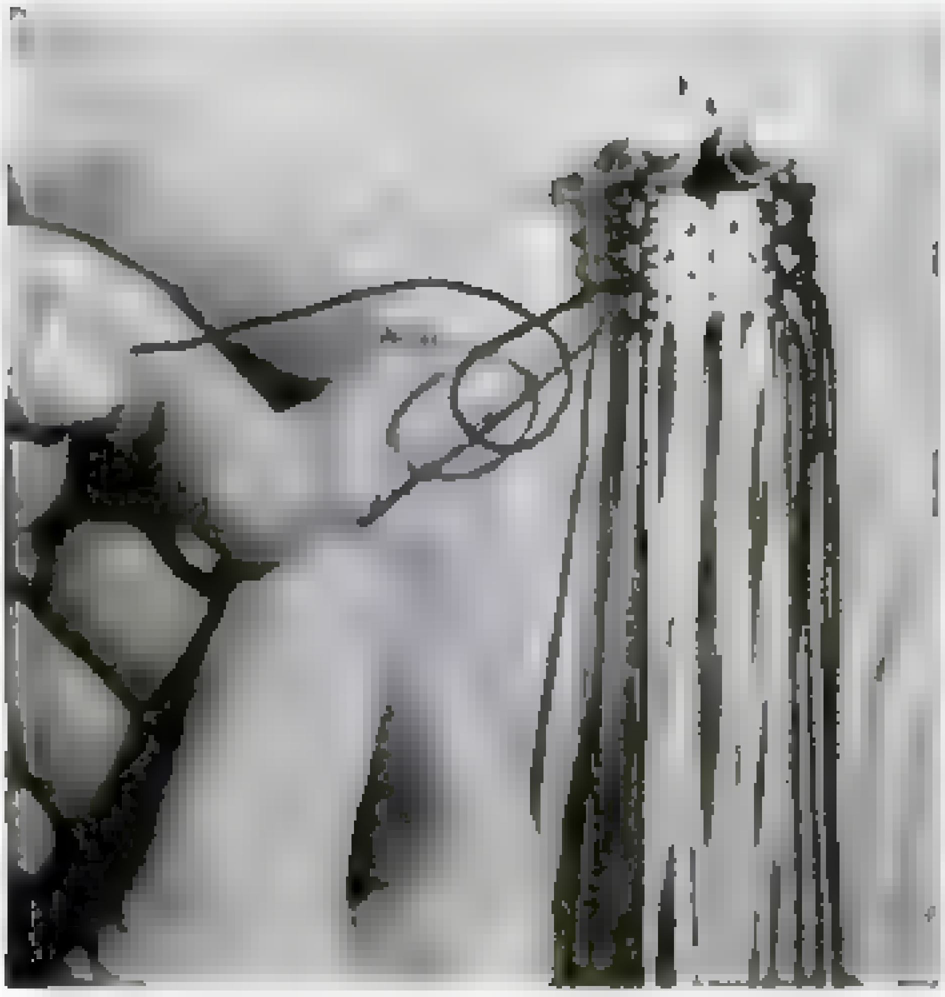


Fig. 3. In knotting the full width of the belt, drop the two outside cords in alternate rows, and tie the outer one in a half hitch over the other

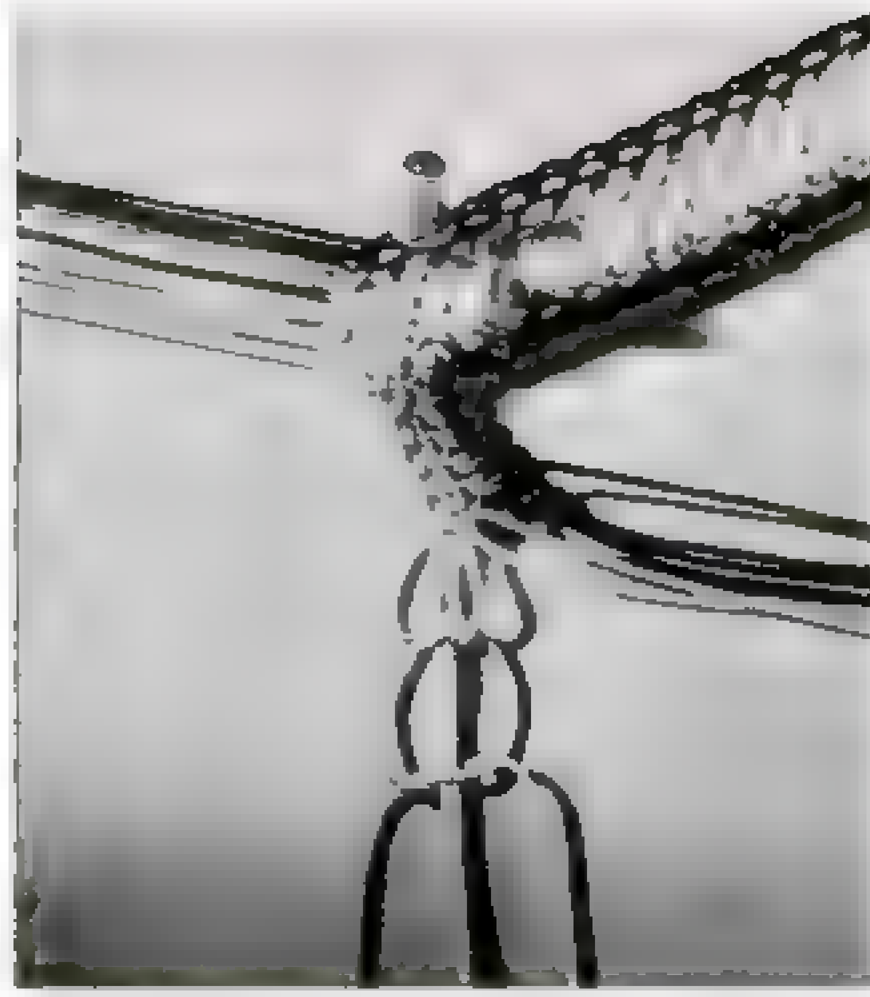


Fig. 4. The keeper loop of the belt is knotted at right angles, then brought to a point on one side, and tied to the remaining cords (left above)

each square knot. If only half of a square knot is tied continuously, a spirally knotted cord results.

Add another push pin and a double strand at each side of the first knot. With each double strand and the adjoining two strands from the first knot, make another square knot (Fig. 2). Next, remove the two outside push pins and close the loops under them by pulling the second strand from each side taut. In the same way, add more strands to each side to bring the belt to its required width. Each time a strand is added to either side, make a row of square knots across the work. In knotting the full width, drop the two outside strands on each side in alternate rows so that all the strands will be knotted together.

The edges will be more even if the free outside cord, on such alternate rows, is tied in a half hitch over the second cord (Fig. 3).

Bring the buckle end of the belt to a point by dropping a knot at *each side* of each succeeding row. Divide the strands in half. Take those on one side and knot a narrower strip at right angles to the belt (Fig. 4) to form a "keeper," which should be as long as two and a third times the width of the belt itself. Bring *one side only* of this to a point; match the strands with the remaining ones of the belt; and tie each pair into tight square knots. Fasten the knots with thin shellac, cellulose cement, or thin varnish. Cut off the cords, turn the loop inside out, slip the other end of the belt through the buckle, then pass it through the keeper (Fig. 5), and draw tight around the buckle.

Fig. 5. The loop is next turned inside out to hide the knots. To fasten on the buckle, pass the end of the belt through it, then through the loop, and draw up tight. Below, the finished belt

Canteen Equipment

By CHARLES HENRY HUNT

President, Long Beach Homecrafters

RED CROSS canteen units are being organized and expanded all over the country, and home craftsmen, workshop clubs, and manual-training classes can all render a real service by making up canteen outfits for these mobile units, which stand ready to furnish food to refugees in case of any major emergency.

Such canteen equipment offers an opportunity for good craftsmanship and ingenuity on the part of the builder in developing refinements that will make it more serviceable.

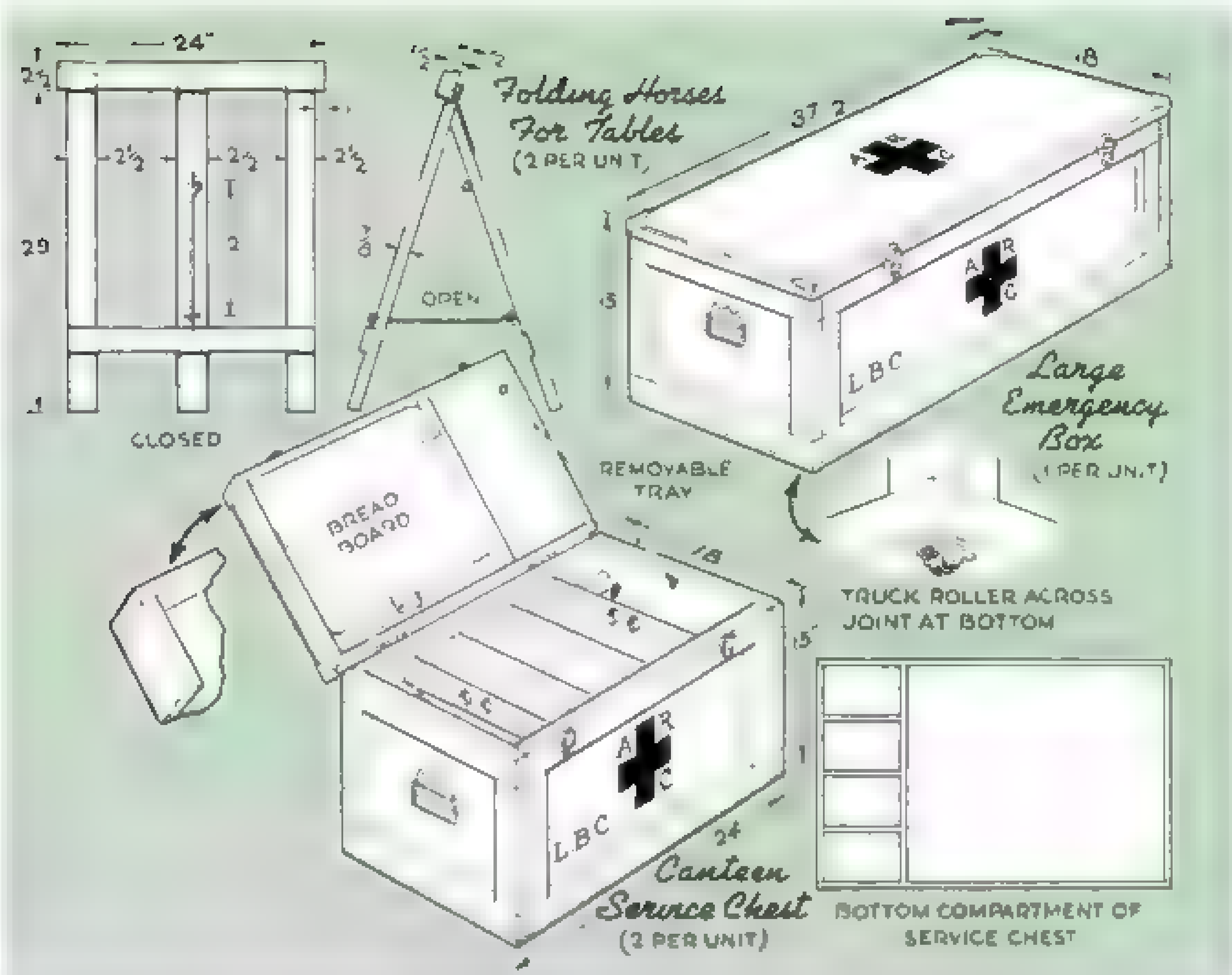
Before starting work, however, contact your local chapter to learn its needs and specifications. Often it will be able to furnish all necessary materials.

The Long Beach, Calif., Homecrafters have built several units such as illustrated above. Needs will vary in different localities and dimensions may have to be altered to suit the type of motor equipment used, but on the whole the design shown will prove satisfactory.

Canteen equipment must be sturdily made to meet service conditions, but it should also be kept as light as possible, in order that women may handle it easily.

The canteen box and chests are made of ½" plywood and ¾" by 2" stock. Hardwood frames are first made for the ends, sides, lid and bottom of each, with dowel, mortise-and-tenon, or simple butt joints. The plywood is glued to these, preferably with waterproof resin glue, and also screwed fast, the screws being inserted from the plywood side and countersunk. Plastic composition wood is used to fill the holes above the screw heads to leave a smooth interior surface.

The upper lid of the small chest, two of which are made for each unit, holds a good-sized bread board and carving knives, a large fork, and a spoon or ladle, all held in place by small metal clips. A removable tray holds ordinary knives, forks, and spoons, and lifts out like a trunk tray, so



for Red Cross Units

that it can be placed on a table for service. Your chapter officials will tell you what trays and partitions are wanted. The chest illustrated is partitioned at one end for 1-qt. canning jars to hold sugar, sandwich spreads, jams, butter, and the like.

Trunk rollers are fastened to the bottoms so that the boxes can be rolled easily on the floor of a station wagon or other service car.

After all corners have been carefully sanded and rounded off, the boxes are oil-stained cherry maple inside and out and given one coat of lacquer sealer or shellac and two coats of clear lacquer or varnish. Rub with steel wool lightly and wax. Such a finish gives a smart appearance, but a paint finish can be applied instead if preferred.

The Red Cross emblem is painted on in red and the chapter name and canteen initials in black before the boxes are varnished. Where several units are made up, the pieces should be numbered.

Brass handles are bolted in place with iron washers inside. Corner plates and two trunk fasteners are used on the lid, which is kept upright when open by a small chain.

The canteen service table is very light and strong; it can be set up by one woman in a few seconds. Taken apart, it fits into a station wagon and takes up little space when nested. The 24½" by 66" top is made of ⅝" plywood, with ¾" by 1¼" pine strips glued and screwed fast around the top edges. All corners are rounded off. The leg horses are separate and can be nested inside the top.

• • •

PINHOLE-SIZED leaks in the bottoms of oil-stove tanks, kitchen utensils, and so forth are often hard to locate even though water or oil runs through freely. The liquid spreads over a large area so quickly that it is hard to see just where the hole is. An easy way to use compressed air for spotting such leaks in open-top vessels is to push the tank or pan upside down into a pail of water until only an inch or so remains above the water. This traps and compresses the air inside. Apply soap lather or saliva to the suspected area. Bubbles will reveal the pinhole.

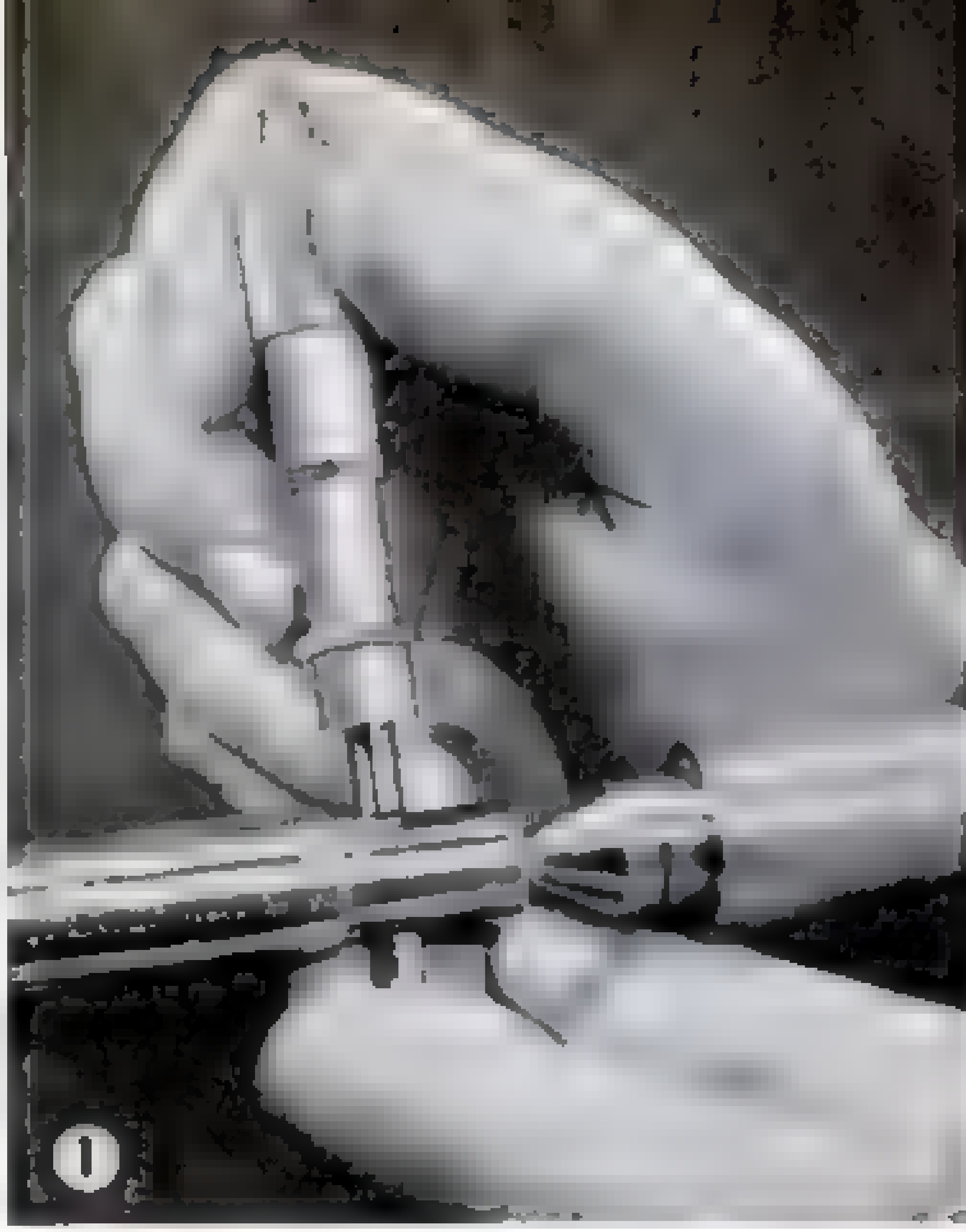
MACHINISTS FOR WAR WORK

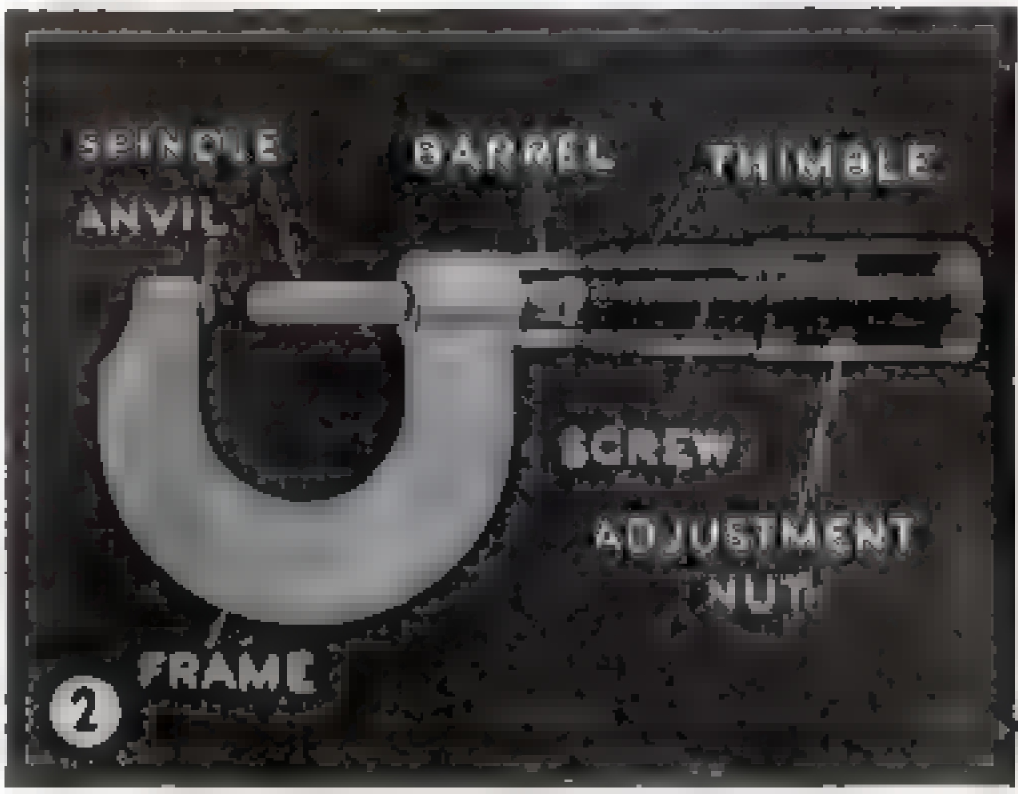
HOW TO READ AND USE

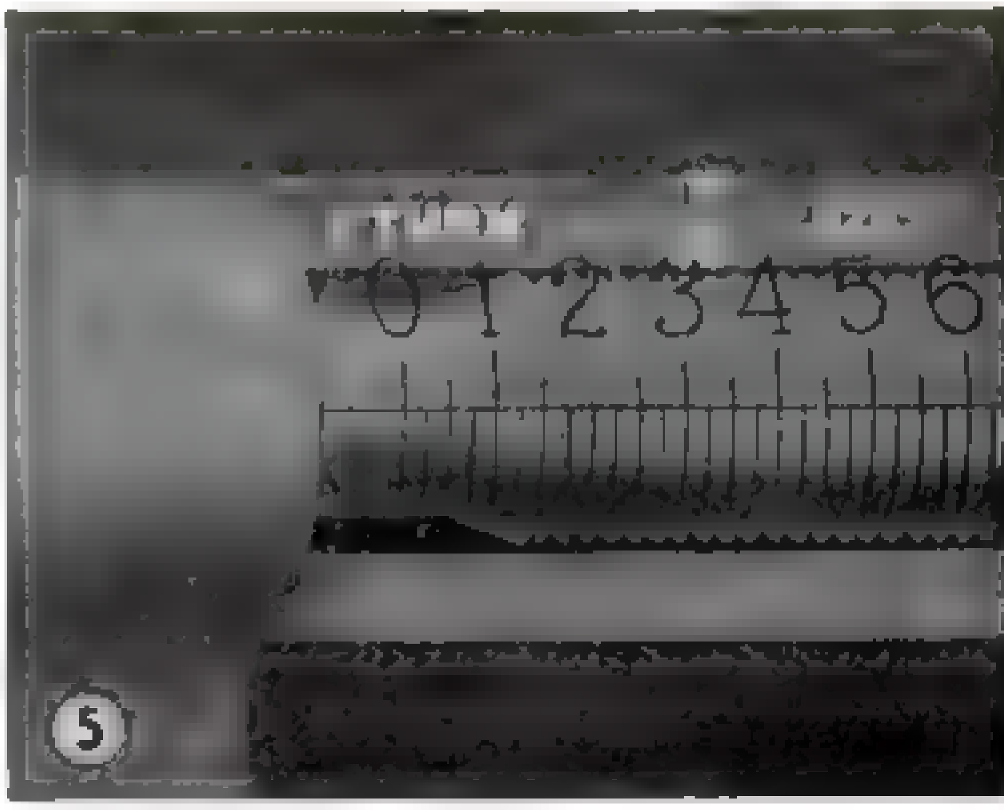
Micrometers

From the U. S. Office of Education training film "The Micrometer"

This article is based upon one of a series of 16-mm. sound films prepared by the U. S. Office of Education for training war workers and distributed for the Government by Castle Films. For the machine-shop student or beginner, the value of these motion pictures cannot be overstated. They explain in the simplest and most graphic manner the operation of the standard tools and machines used in industry. Make every effort to see these films if they are being shown in your community.







IN THE early days of the locomotive, when cylinders were bored with chisels fixed in wooden boring blocks, a piston was considered a good fit if the gap between it and the cylinder wall was nowhere greater than ⅛". To build better machines, new methods of measuring as well as machining had to be developed. The unaided eye and hand are instruments far too crude to deal with the close limits necessary in fine machine work. It was necessary to invent measuring tools that would magnify differences of a thousandth of an inch or less to be visible to the eye.

The principle of the screw and that of measurement between contacts instead of by visual alignment were applied to solve the problem. They are embodied in the most important measuring tool in the machine shop—the micrometer.

Different types of micrometers are used to measure widths or diameters, inside dimensions, and the depth of holes or slots, but all are based on the same principle. The most common one is the micrometer caliper, used for measuring thickness, diameter, and other outside dimensions. It is often called simply the micrometer or the "mike." In Fig. 1 it is shown being used to measure a diameter in the lathe.

Figure 2 shows the principal parts of a micrometer. At one end of a sturdy U-shaped frame is mounted a hardened steel anvil. The other end of the frame supports a cylindrical barrel, sometimes called the sleeve. This is threaded to engage the mi-

crometer screw, the unthreaded portion of which extends through the frame to become the hardened steel spindle. At the other end, the screw is fastened to a thimble, which rotates with it.

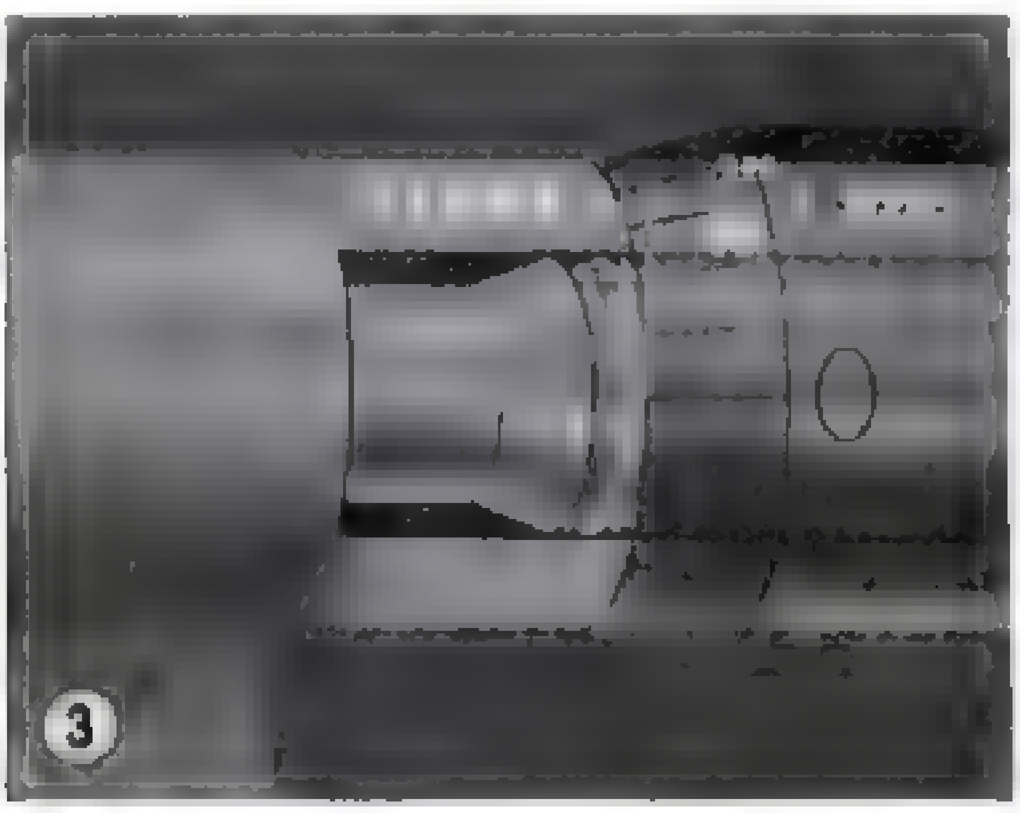
The micrometer screw has 40 threads to the inch. Therefore, when it is turned through 40 revolutions, the spindle will move 1". One turn will move the spindle 1/40th of an inch, or 25 one-thousandths of an inch (.025"). This is shown in Fig. 3.

To show how many complete turns the spindle is away from the anvil, the stationary barrel is graduated as shown in Fig. 4. Each graduation represents one turn, or .025". Four graduations therefore represent .100", and each fourth graduation is made longer and numbered in order from the zero point on. However, instead of marking these .100, .200, and so on, the zeros are dropped and the decimal points omitted to make the scale easier to read. The barrel is marked with plain numerals as shown in Fig. 5, but these are read as hundreds of thousandths.

If we take the full distance around one thread (.025") and make a straight line of it, we can easily divide that line into 25 equal parts, each of which will represent a .001" movement of the spindle (Fig. 6). Let us imagine these graduations extended and marked instead on the circumference of the thimble, as shown in Fig. 7. These can be successively aligned with the horizontal line that runs the length of the barrel (Fig. 5) and each will represent a spindle movement of .001".

Now we are ready to read the micrometer. Figure 8 shows a close-up of the barrel and thimble. We start by reading the highest number visible on the barrel. This is six, but remember that these figures must be read as hundreds of thousandths. Therefore we read it .600". But beyond the figure six another graduation is visible. This gives us .025" more. Now we note that the zero mark on the thimble is not aligned with the horizontal line on the barrel—it is the .001" graduation that is aligned. We add this to the other figures and total all three. The micrometer reading is .625".

(Continued)



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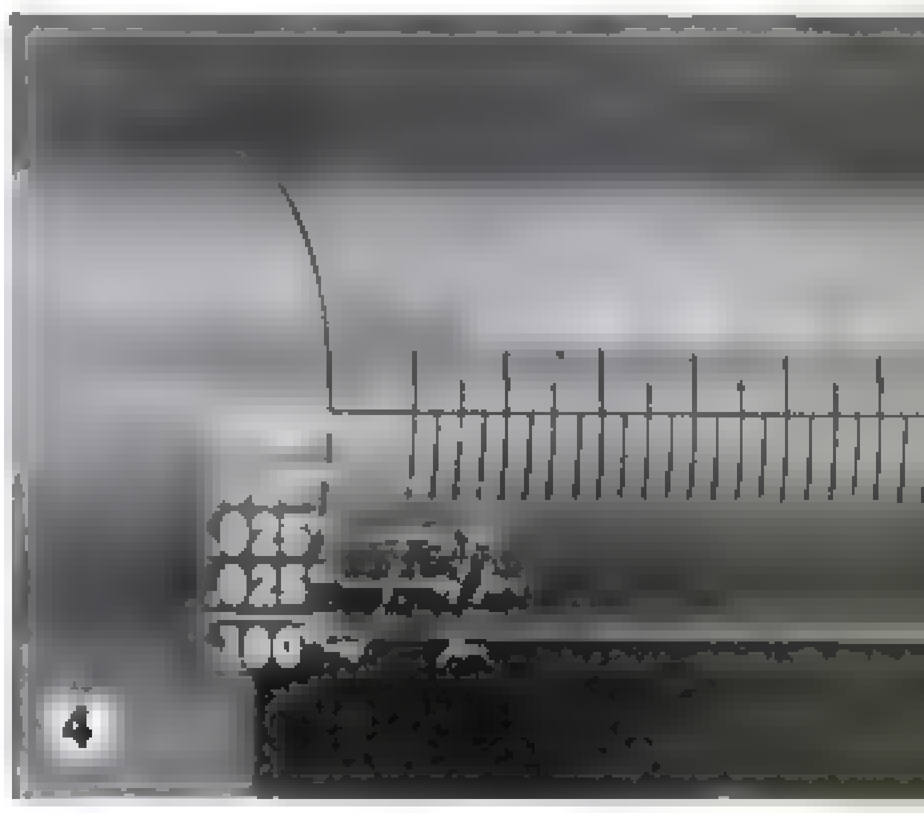

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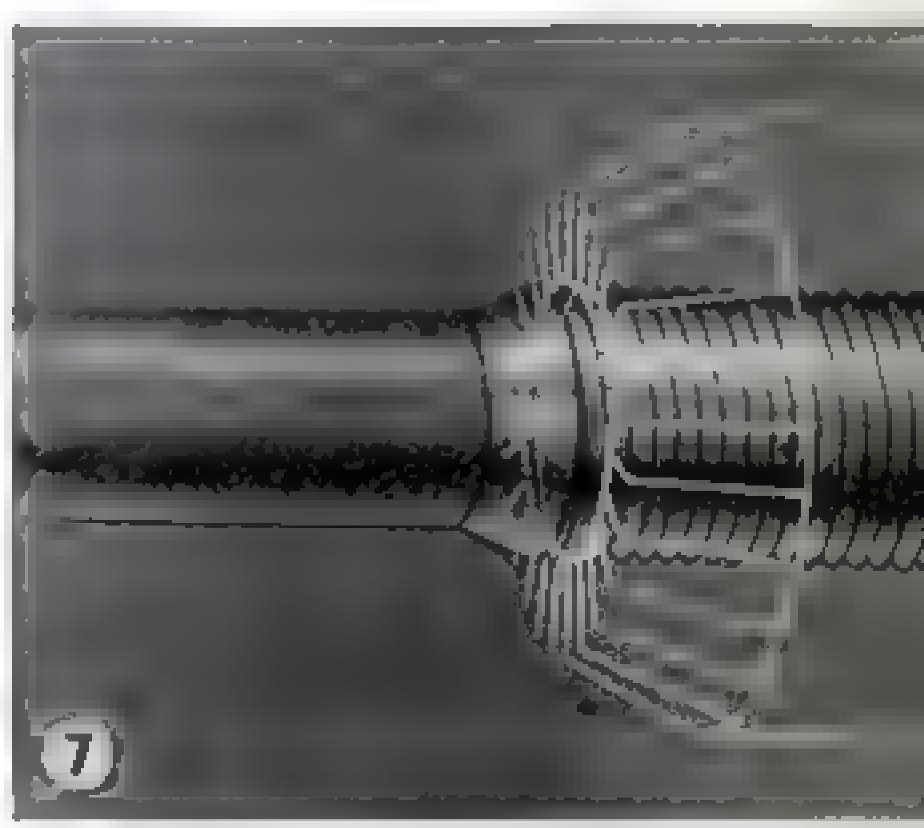


7

The ability to take accurate measurements with a micrometer depends on skill in its use. The screw must not be turned up tightly against the piece to be measured, or a false reading will be obtained. Nor, on the other hand, can it be left loose.

There is a "feel" acquired only through practice that tells the skilled operator when he has turned the thimble with just the right pressure. Until this is acquired, a beginner may measure the same piece at the same point and get slightly different readings each time, but practice will soon enable him to obtain uniform ones.

Gentle pressure of the thumb and index finger on the thimble is sufficient to turn the spindle against the work. As it touches, the slight drag of the fingers over the knurled part of the thimble informs the operator when he has turned it to the proper point of full but not forced contact.

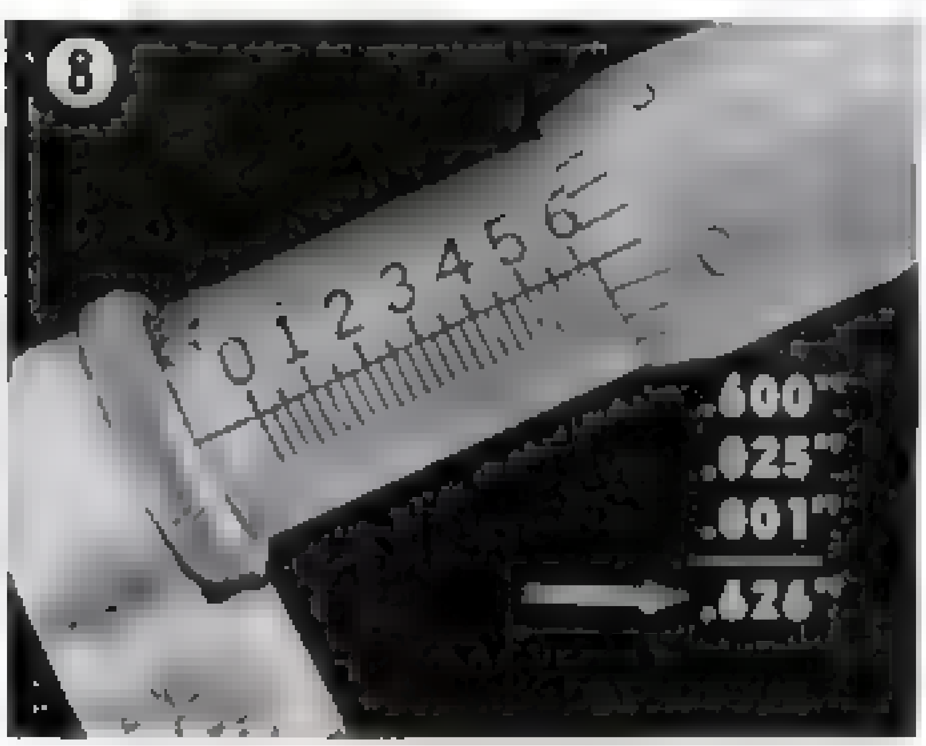
Carelessness in using the micrometer will give false readings, distort the fine threads on the screw, and soon ruin the instrument. It must not be clamped up tightly against the work, nor opened and closed by swinging it by the thimble.

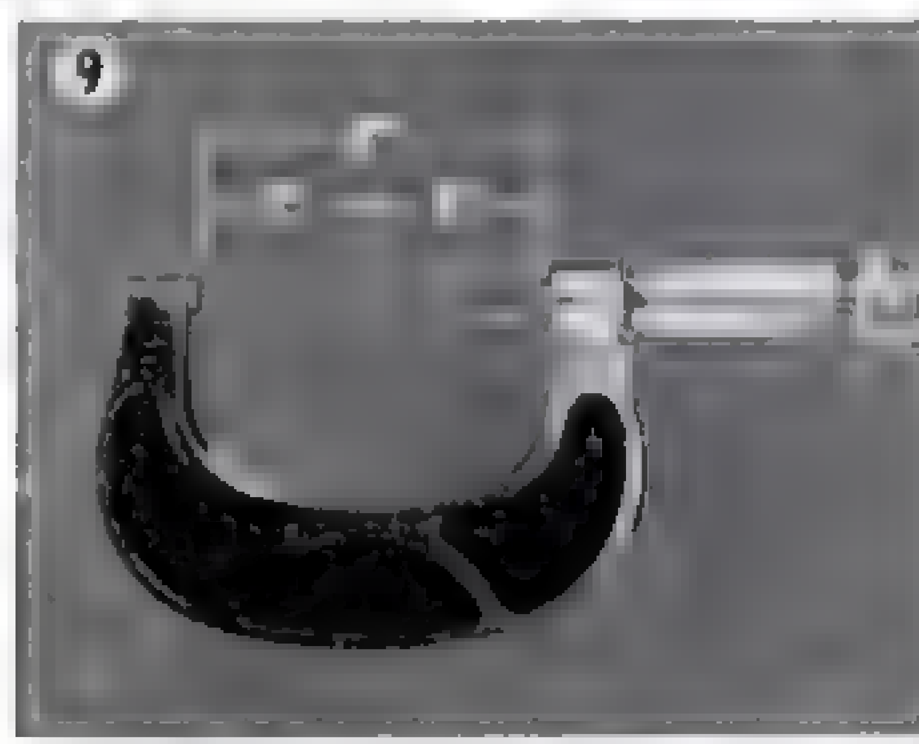
Many modern micrometers have a ratchet stop—a smaller knurled part at the extreme end of the thimble, with a spring ratchet mechanism inside. The spindle can be turned up by this into contact with the work, after which further turning will merely slip the ratchet. To a great extent this eliminates the need of "feel."

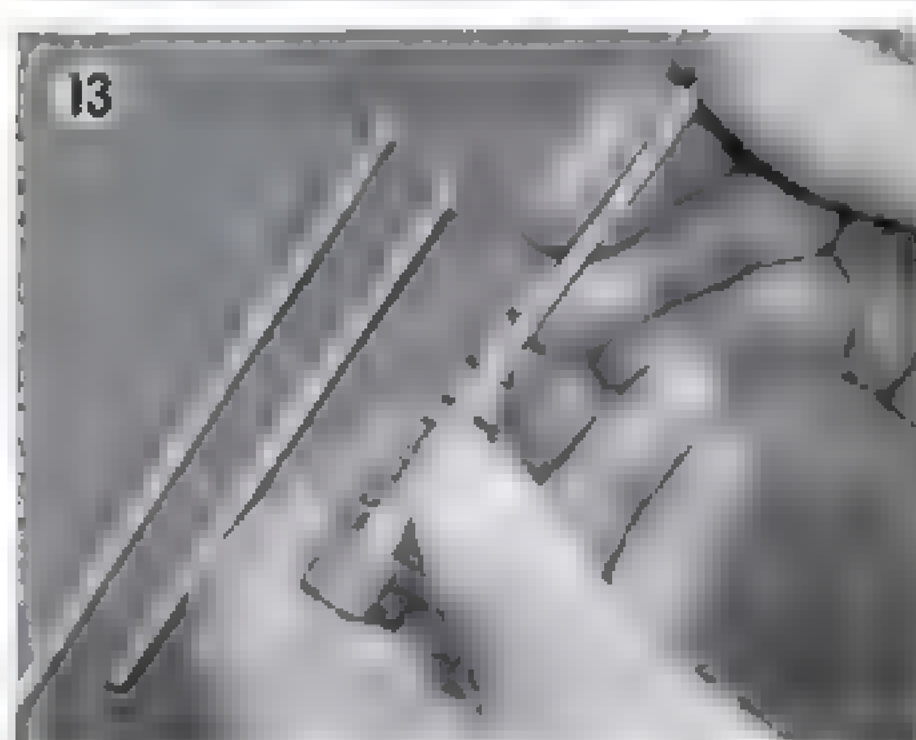
Since the micrometer measures such minute values, it is plain that burrs or nicks on the work, or even dirt on the work, anvil, or spindle surfaces, will result in false readings. Be sure the work is smooth and the micrometer measuring surfaces are clean. In "miking" a long shaft or other piece, take readings at several places.

Micrometers are often used in measuring two or more pieces of material placed together. The same precautions as to nicks and dirt apply with redoubled force. Let us take an imaginary reading of two pieces of flat stock about 1" and ¾" thick. Since the total thickness is over 1", we shall have to use a 2" micrometer such as in Fig. 9.

Micrometers come in standard sizes, designated by the largest opening, in steps of 1". Most sizes, however, measure only the last inch in thousandths. A 1" micrometer measures from zero to 1" in thousandths.







The 2" instrument in Fig. 9 measures from 1" to 2" in thousandths. A 3" one would measure from 2" to 3" in thousandths, and so on.

We use our 2" micrometer, therefore, and obtain the reading shown in Fig. 10. Can you give the dimension indicated before reading farther?

The last numeral visible on the barrel is seven, which gives us .700". There are two full divisions visible beyond it, so we add twice .025", or .050". The .001" graduation on the thimble is aligned with the index line. Adding this we obtain as a total .751". But we are using a 2" micrometer, so 1" must be added. The thickness of the two pieces we measured is therefore 1.751".

The standard micrometer, in experienced hands, will measure accurately to one half of a thousandth (.0005") and less, since the thimble graduations are large enough for the eye to subdivide in halves and even quarters. Vernier micrometers have an extra scale on top of the barrel (visible in some of the photographs) that permits readings to .0001". Such vernier scales will be fully described in a future article.

All micrometers in constant use should be checked frequently. This is done by closing the spindle against the anvil. When the surfaces are in contact, the zero line on the thimble should line up with the barrel index line. Most micrometers have means of adjustment to compensate for wear. Those larger than 1" are checked with special standards or gauge blocks—a 2" micrometer is checked with a 1" standard, a 3" one with a 2" standard, and so forth. When closed over the standard with just the right feel, the micrometer should register zero.

A companion tool to the outside micrometer is the inside micrometer, which is used for measuring holes, the width of slots, and the like. The jaws of this instrument expand against the inside surfaces. It must be held square with them and across the diameter of the hole, as shown in Fig. 11.

Figure 12 shows a reading obtained with the inside micrometer. It may look familiar at first glance, but here appearances are deceiving. The figures on the barrel run backward, so we read first the figure just before the last one visible—four, not five. Three divisions following the four are also concealed by the thimble, which gives us .075" more. And now if we hastily add

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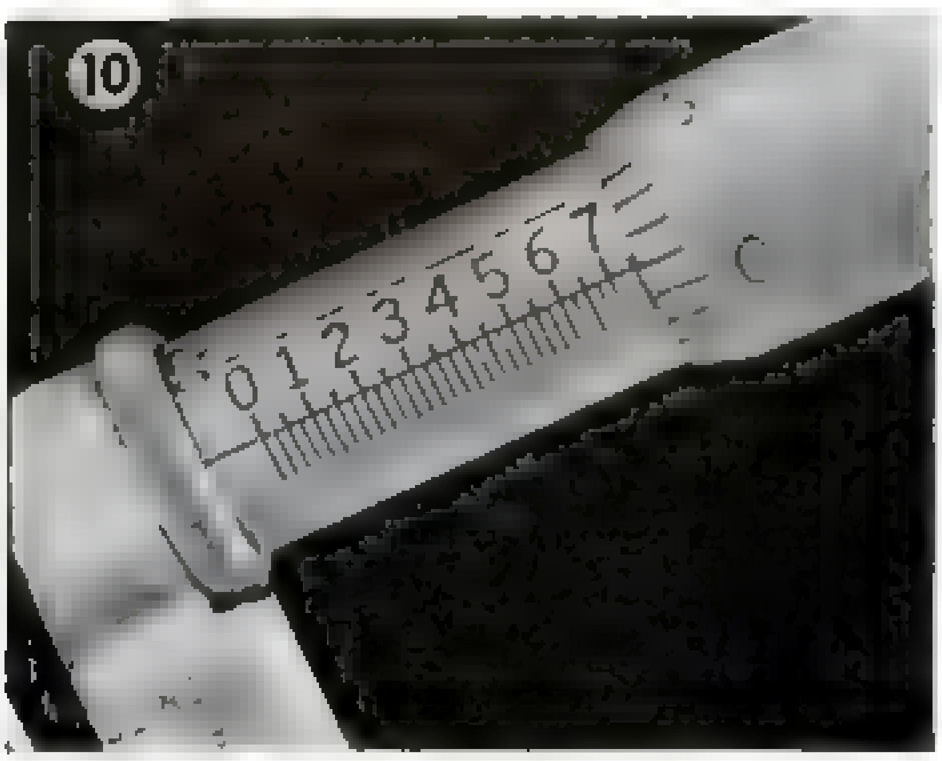

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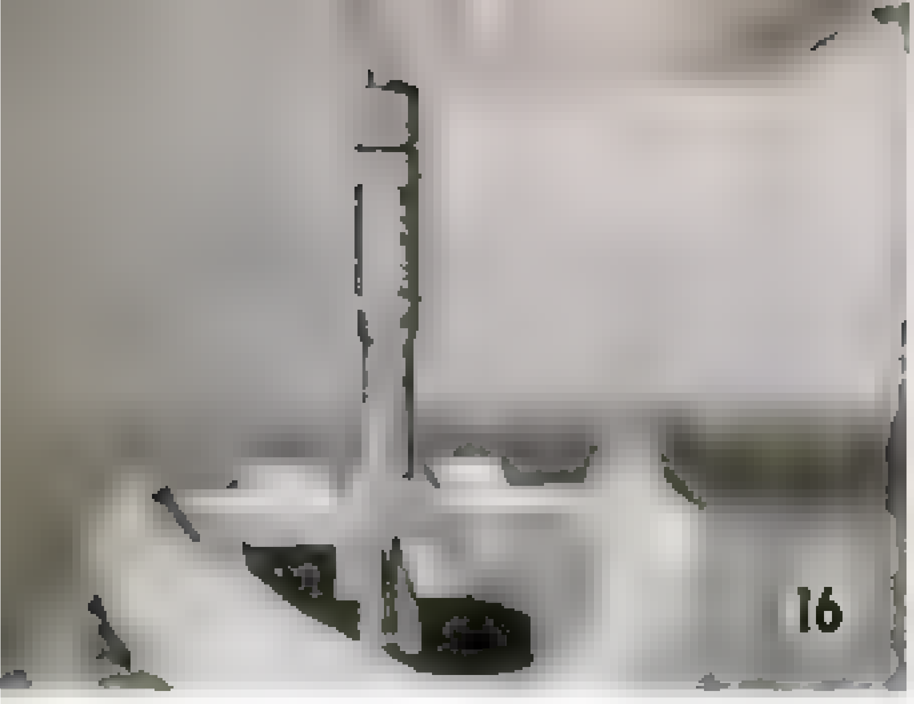


.016" as the thimble indication we'll be wrong, for the thimble graduations also run backward. It is the .014" division that is aligned. Our reading is .489".

Another type of inside micrometer makes use of interchangeable rods of standard lengths to measure the diameter of large holes, as shown in Figs. 13 and 14.

A convenient tool for "miking" holes indirectly is the telescoping gauge shown in Fig. 15. One part of the head slips into the other against the pressure of a spring. The gauge is inserted in the hole, and the spring keeps the head expanded as far as the hole permits. A turn on the handle locks the head. The gauge can then be removed and measured with an outside micrometer.

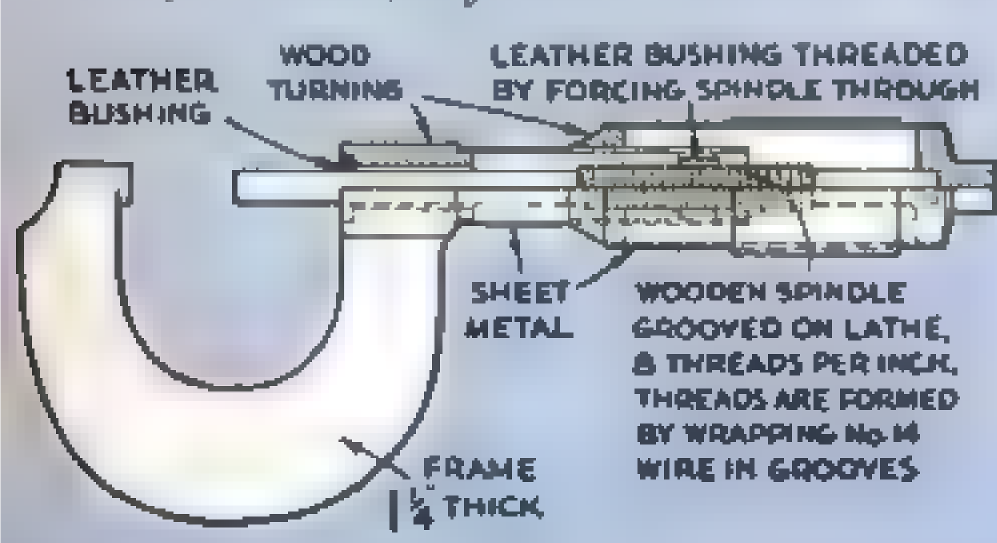
The depth micrometer (Fig. 16) is also used with rods of various standard lengths for measuring the depth of keyways, slots, holes, and so forth. Its scales also read backward, like those of the inside micrometer. The reading in Fig. 17 was taken with a 1" rod in the micrometer.

In using a micrometer, remember that it is a precision instrument and must be kept clean and used with care. Never leave it where it may fall to the floor, or where it may pick up abrasive articles—under a grinding wheel or in the filings on a bench top, for example. Oil it occasionally and keep it in a case or some other place where it will not be damaged by heavy tools. Check it frequently and keep it adjusted so that it turns neither too freely nor tightly.

Last but not least, always keep the spindle and anvil separated by a fraction of an inch when the instrument is not in use, to prevent corrosion of the contact surfaces.

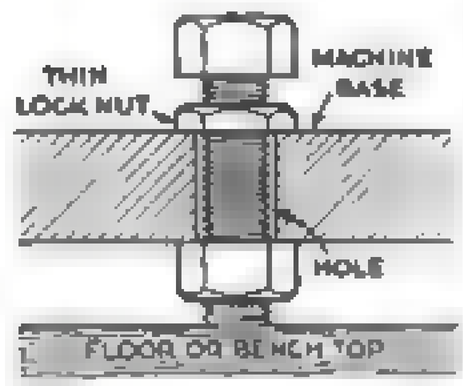
Giant Wooden Micrometer Used in Teaching War Workers

A GIANT micrometer, five times actual length (scale, 5" equal 1") is used at the Patterson Park High School, Baltimore, Md., as a help in teaching a women's defense training class how to read this instrument. This demonstration model, shown at the right, was made of wood and sheet metal, and actually works. It can easily be read 15' away.—E. B. HAFFNER.



Bolts Serve as Adjustable Feet for Leveling Machine Tools

MANUFACTURERS of machine tools recommend that equipment be set up level for best results, but this is hard to do when the shop floor is uneven. Although wedges are often used, they are neither secure nor permanent. However, by using hexagon-head bolts and nuts as shown in the drawing, you can level the machine simply by turning the boltheads with a wrench. Thin lock nuts may be used above the base if desired. Hold a spirit level on a smooth, finished surface, such as the column in the case of a drill press, to check the alignment of the machine. It should be noted that a three-point suspension of this type is most desirable.—R. H.



Nailing Guide Aids in Fastening Large Sheets of Wall Board

IN APPLYING large wall-board sheets, the location of studs or furring strips may be marked on a plywood strip or lath as long as the width of the wall board. It is then easy to locate the proper nailing spots by holding the marked piece in front of the new material and nailing in line with the marks. One end of the guide should be marked with an arrow, especially if nailing supports are not regularly spaced from each side.—L. S. CLARK.

SOLVING TRIANGLES [CALCULATIONS]

Triangles can be solved to within 98 or 99 percent accuracy without reference to tables of trigonometric functions by the use of the following series of numbers, which should be memorized **2, 4, 8, 10, 12, 14, 16, 17, 17.** These numbers are progressively added in reverse order to give the sine and cosine of angles to 90° in steps of 10° as follows.

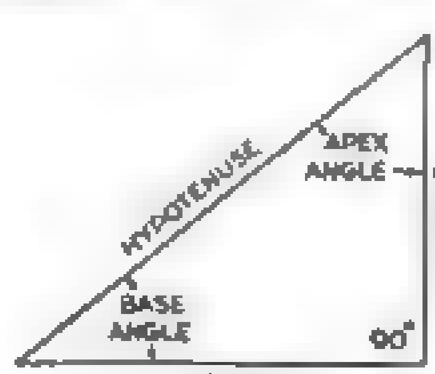
Sine 0° =	.00	= Cosine 90°		Sine 50° =	.76 (64 + 12) =	Cosine 40°
" 10° =	.17 (0 + 17) =	" 80°		" 60° =	.86 (76 + 10) =	" 30°
" 20° =	.34 (17 + 17) =	" 70°		" 70° =	.94 (86 + 8) =	" 20°
" 30° =	.50 (34 + 16) =	" 60°		" 80° =	.98 (94 + 4) =	" 10°
" 40° =	.64 (50 + 14) =	" 50°		" 90° =	1.00 (98 + 2) =	" 0°

The value of intermediate angles may be calculated by proportional parts. For example: Sine 67° = .86 + .7 (.94 − .86) = .86 + .056 = .92

Other functions can be calculated by means of the following formulas:

Sine of base angle = height ÷ hypotenuse = cosine of apex angle
Sine of apex angle = base ÷ hypotenuse = cosine of base angle
Tangent of base angle = height ÷ base
Tangent of an angle = sine of angle ÷ cosine of angle

When two of the three factors in any one of these formulas are known, the other can be calculated easily.



POPULAR SCIENCE MONTHLY SHOP DATA

Faceplate Miller

MACHINES LARGE WORK ON A SMALL LATHE

By FOSTER C. SINEX

Fig. 1. The cutting edges of the tool bits, set to the same radius, are adjusted by use of an indicator so as to project equally from the faceplate

TWO or more easily made tool holders mounted on the faceplate of your lathe will enable you to face large castings or forgings that could not be machined in the ordinary way. This is a particular advantage under present circumstances, when equipment is scarce and the tools on hand must be made to do double and triple duty. Nowadays, the small lathe is being called on to tackle man-sized jobs. This is one way in which yours can take on work beyond its customary size.

The work is, of course, mounted on the compound rest as shown in Fig. 2. The cutting speed of the tools can be varied by sliding the holders in the faceplate slots to different diameters, and also by reversing the holders to place the tool bits on the inside, closer to the spindle center. With one holder on a ⅛" shorter radius than the other and its tool bit set to project .020" farther from the faceplate, it is possible to make a roughing cut and a slower finishing cut in one pass of the work.

Where much work is to be done, four or six tool holders—as many as there are slots

Fig. 2. Taking a roughing and a finishing cut simultaneously on a 45-deg. bracket. This is done by setting one tool holder on a ⅛" shorter radius than the other, with its tool projecting .020" farther

Fig. 3. As many tool holders may be used as there are slots in the faceplate. Here six have been put in place to speed the cutting

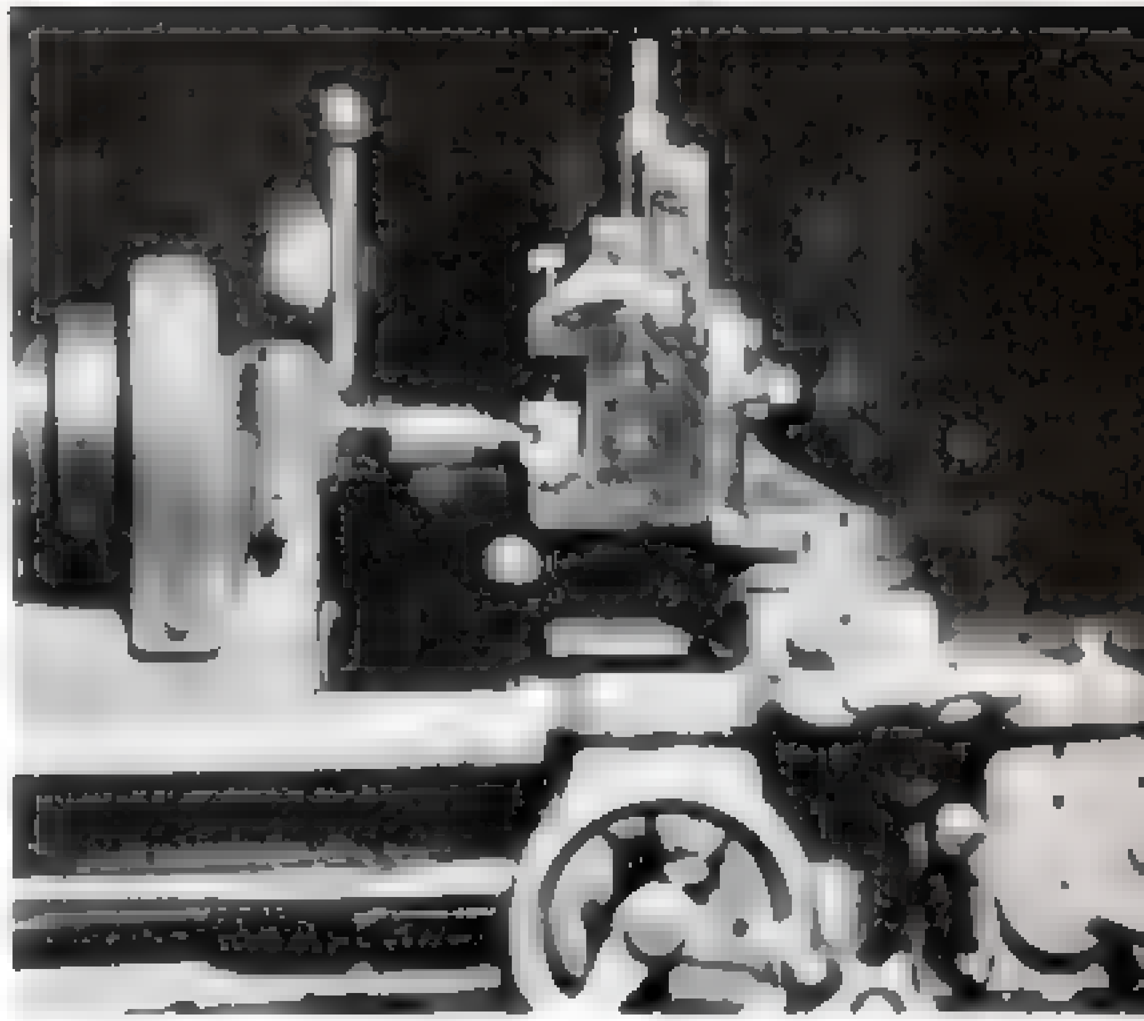


Fig. 4. A piece of stock long enough for two tool holders is used, and, with the aid of the milling attachment, a slot for the bits is cut along the length of one face

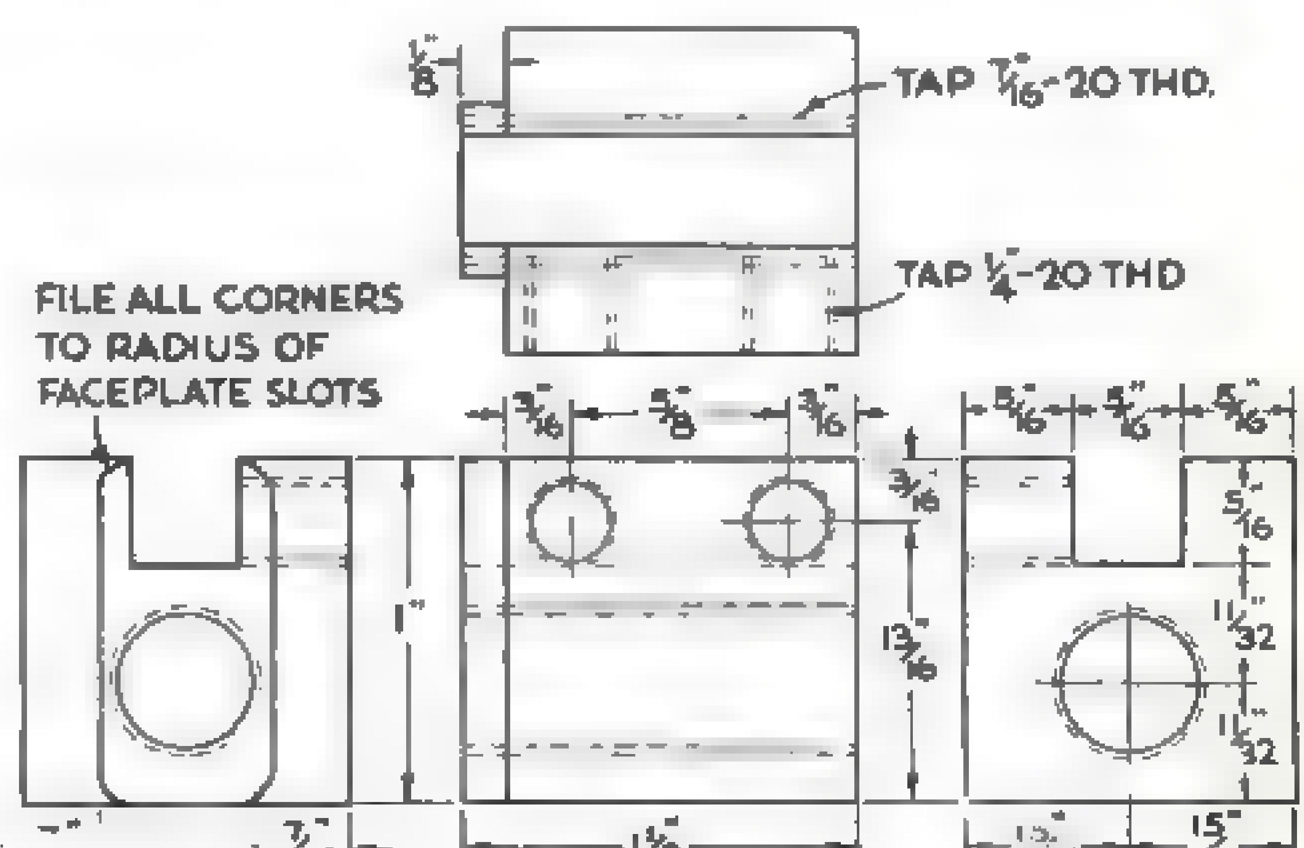
in the faceplate—may be used as shown in Fig. 3 for faster cutting. The tool bits are all set to the same radius and are adjusted with a dial indicator (Fig. 1) so that all project the same distance from the faceplate.

Two tool holders can be made from a piece of 1" square key stock 2⅜" long. A 5/16" by 5/16" slot is first milled along the entire length of one face. This can be done in a milling attachment on the lathe, as shown in Fig. 4. Four setscrew holes are laid out, drilled 13/64", and tapped ¼"-20.

The work is then cut in half. Each piece is faced to length, and the holes for the anchor bolts are drilled 25/64" and tapped 7/16"-20. Hexagon-head bolts of this size can be found in automobile junk yards.

The milling attachment again comes into play for shaping the tongue on one end of each holder. For use on a faceplate that has no slots, the tongue is omitted, but each tool holder is fitted with a steel dowel (in addition to the 7/16" bolt) to prevent turning. A slotted faceplate is preferable because it permits rapid adjustment of the holders.

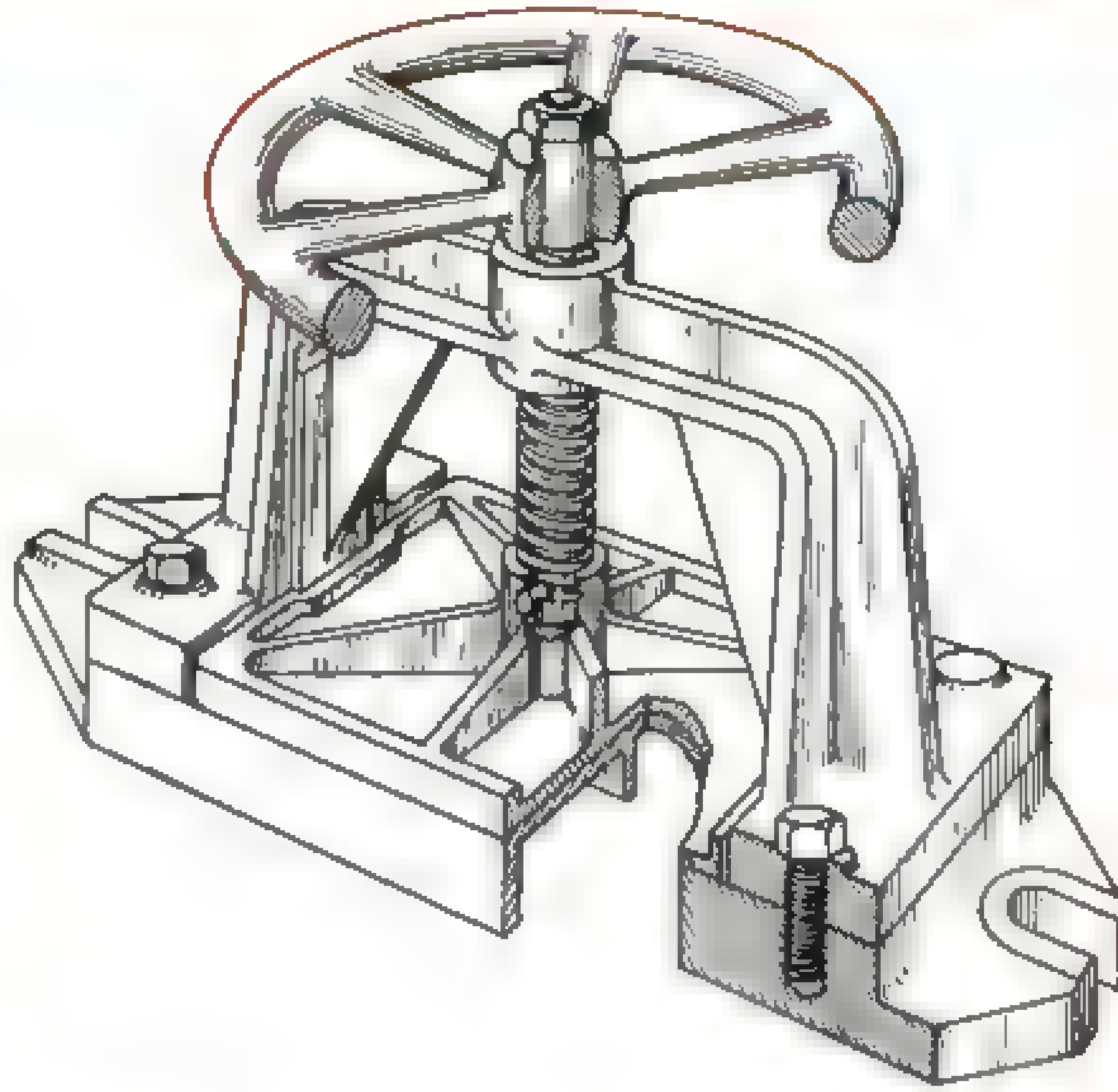
Ordinary 5/16" lathe tool bits are used in the tool holders; high-speed bits are, of course, best. They may be ground for rough and finishing cuts exactly as for use on the lathe. An angle plate will be found convenient for mounting work securely on the compound rest.



Measurements for the tool holder, as faced to length and tapped, are shown here. Best results are obtained if high-speed bits are used in these holders

What's Wrong?

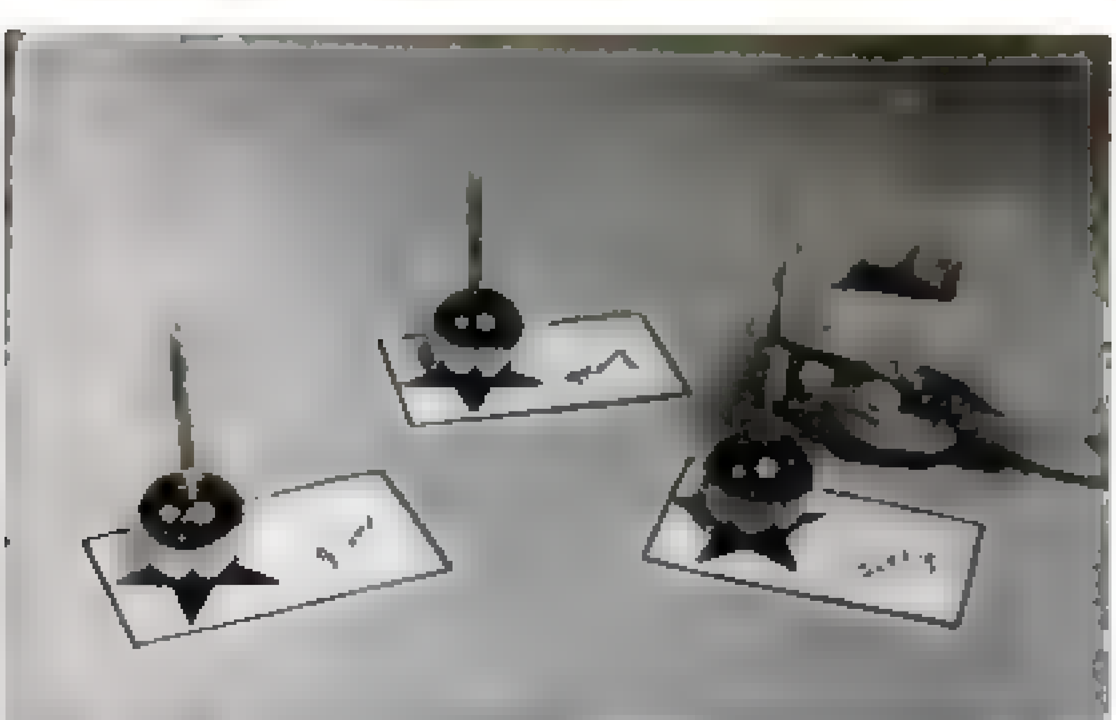
EIGHT ERRORS IN MECHANICAL DESIGN



HOW quick are you at catching mistakes in mechanical design? Here is a perspective drawing of a small hand press, with some portions cut away to show the construction more plainly. Eight things are wrong. Can you tell what they are? After making check marks to indicate the mistakes on the drawing, turn the page upside down and compare your answers with our list.

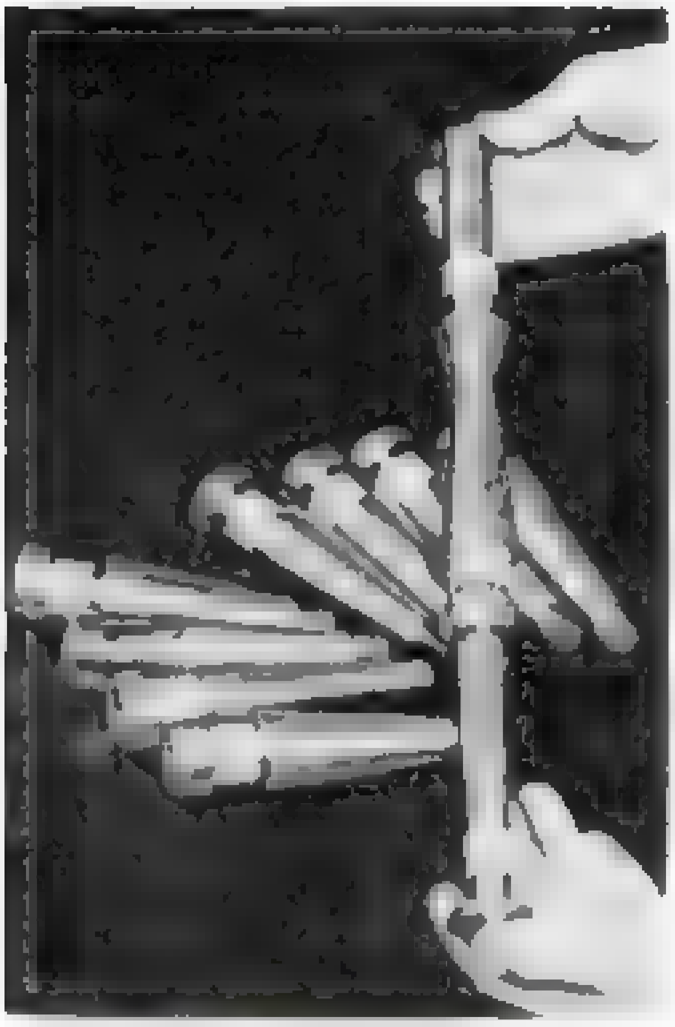
1. The triangular ribs inside the yoke would prevent the platen from rising.
2. As the screw has a left-hand thread, turning it clockwise, which should close the press, would open it instead.
3. The handwheel spokes should be thin at the rim and thick at the hub, where the leverage and stress are greatest.
4. That part of the stem on which the handwheel fits is too long; the nut could not be tightened down to bear against the wheel.
5. There is no key to keep the handwheel from turning on the stem.
6. A pin through the platen collar and into or through the stem would keep the latter from turning. The pin should be at the side, engaging the annular groove around the stem, which could then turn but not pull out.
7. One boss at the right-hand side of the yoke has not been drilled.
8. For a good clamping action, the hole in the yoke shown in section at the right should not be tapped, but drilled clearance size for the screw. Only the base hole should be tapped.

Small Christmas-Tree Ornaments Dress Up Table Place Cards



UNUSUAL and attractive place cards for the Christmas dinner table are easily made by utilizing small tree ornaments as decorations. Stick a large and brightly colored gummed star at one end of a small white card. Remove the metal cap from a small Christmas-tree ball ornament and mount this on the star with a bit of melted wax as illustrated at the left. Insert a red or green birthday candle in the neck opening. The name may be written or printed on the card with black or colored ink.

MACHINISTS FOR DEFENSE

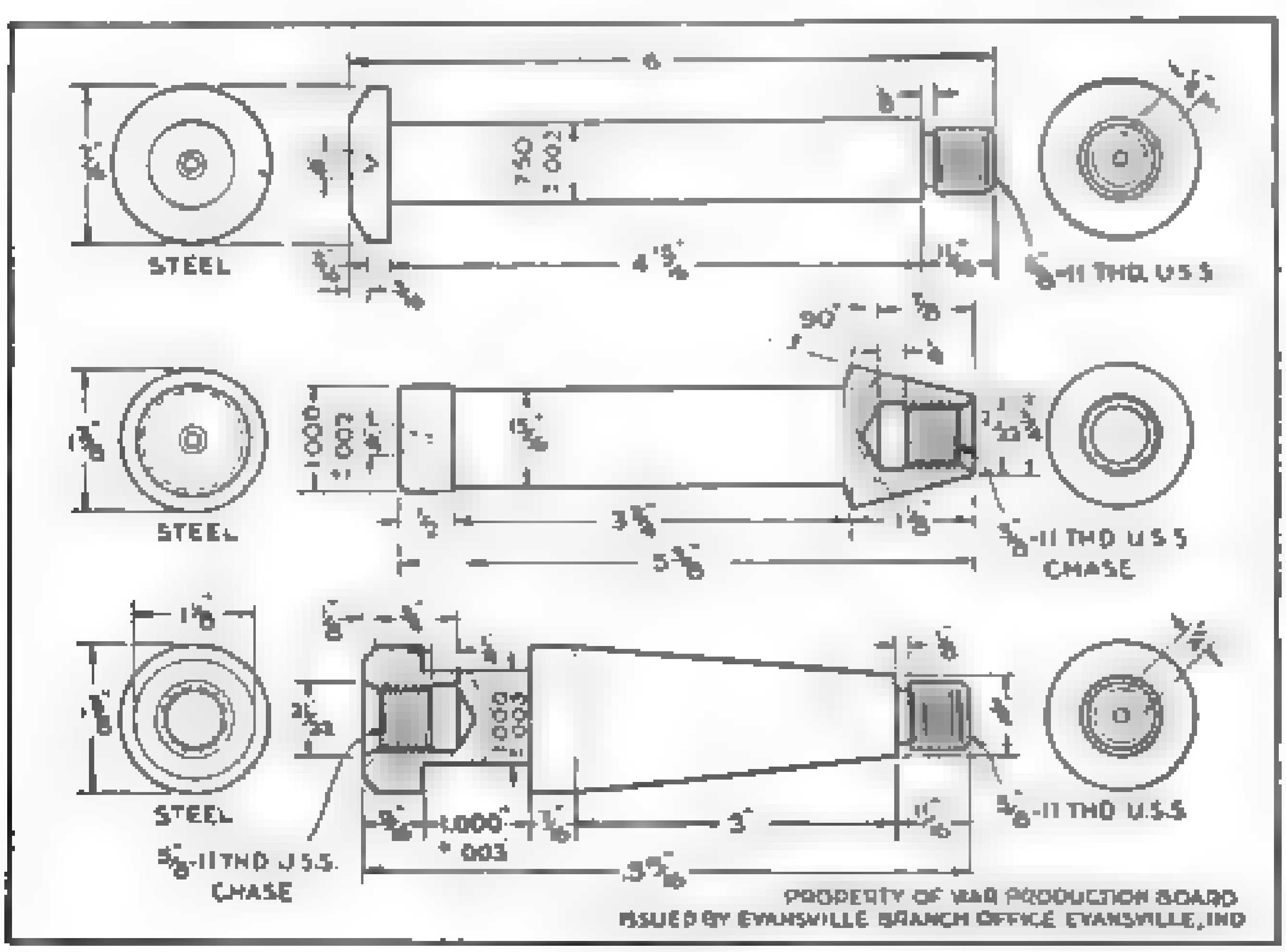


Home craftsmen and small subcontractors desiring war work are given simple tests by the WPB in Evansville, Ind. Ralph C. Hubert, left, office manager, and Chief Engineer William E. Brown are here examining pieces made in home workshops. Left, samples

WPB Engineer Devises Simple Test for War-Work Machinists

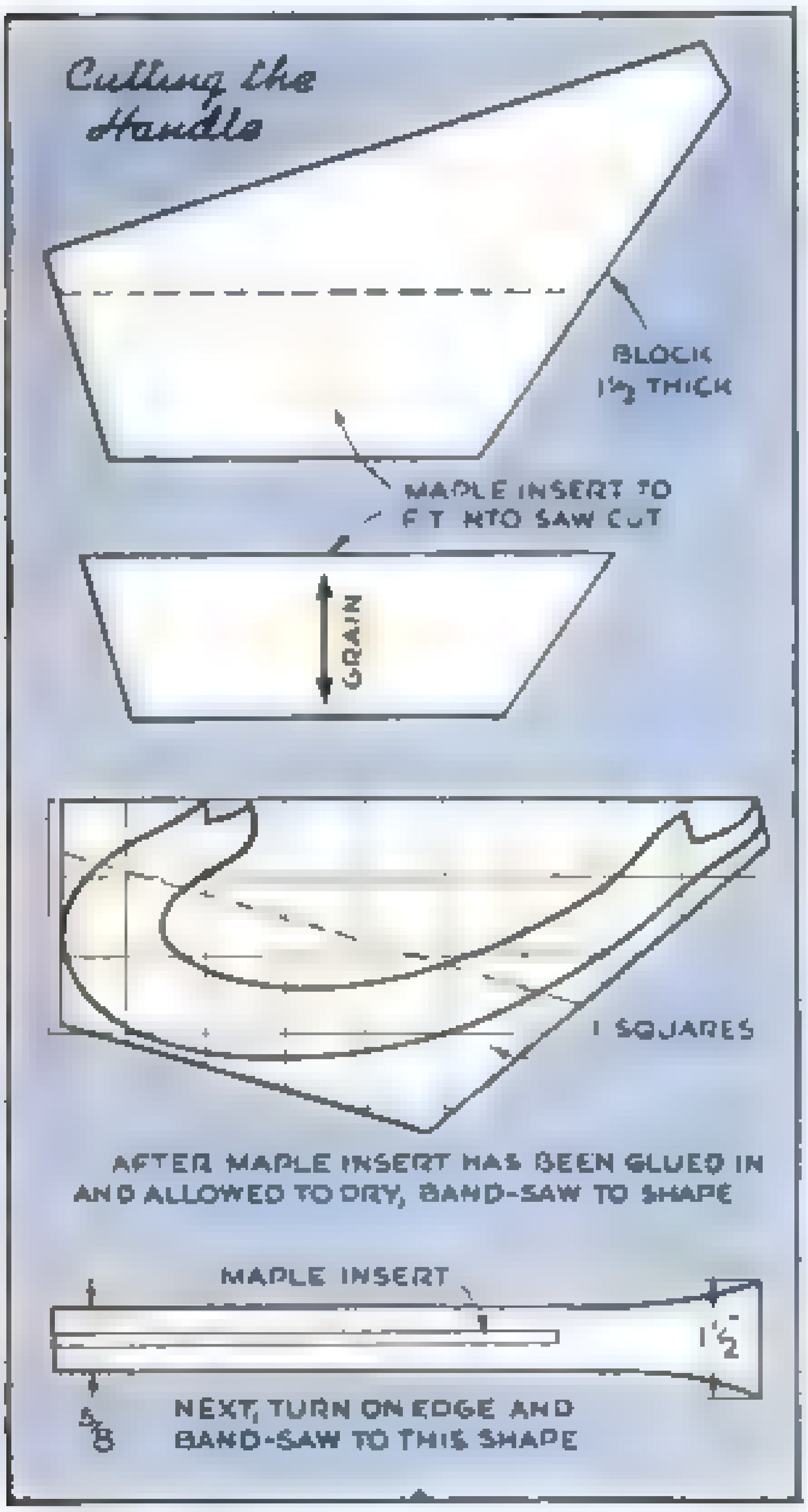
IF YOU are thinking of becoming a war-work machinist or wish to obtain subcontracts for "bits and pieces," but are uncertain as to your ability to meet average requirements in respect to workmanship and accuracy, you can test yourself by making the three parts shown in the accompanying drawings. Then take them to some experienced machinist, toolmaker, or mechanical engineer and ask him to check them for you. If he passes them, you need have no hesitation in trying to get war-production work.

The test was devised by William E. Brown, chief engineer of the War Production Board's branch office in Evansville, Ind., and is being used by Ralph C. Hubert, manager of the office, to test the skill of home craftsmen and small-shop owners who have registered for war work. It will be noted that the pieces have to be made to comparatively close tolerances. Merely screwing them together gives a rough test of the accuracy of the work.



Machinists on war work follow close tolerances. Could you make these three parts within the specified limits?

Doubledecker Tidbit Tray



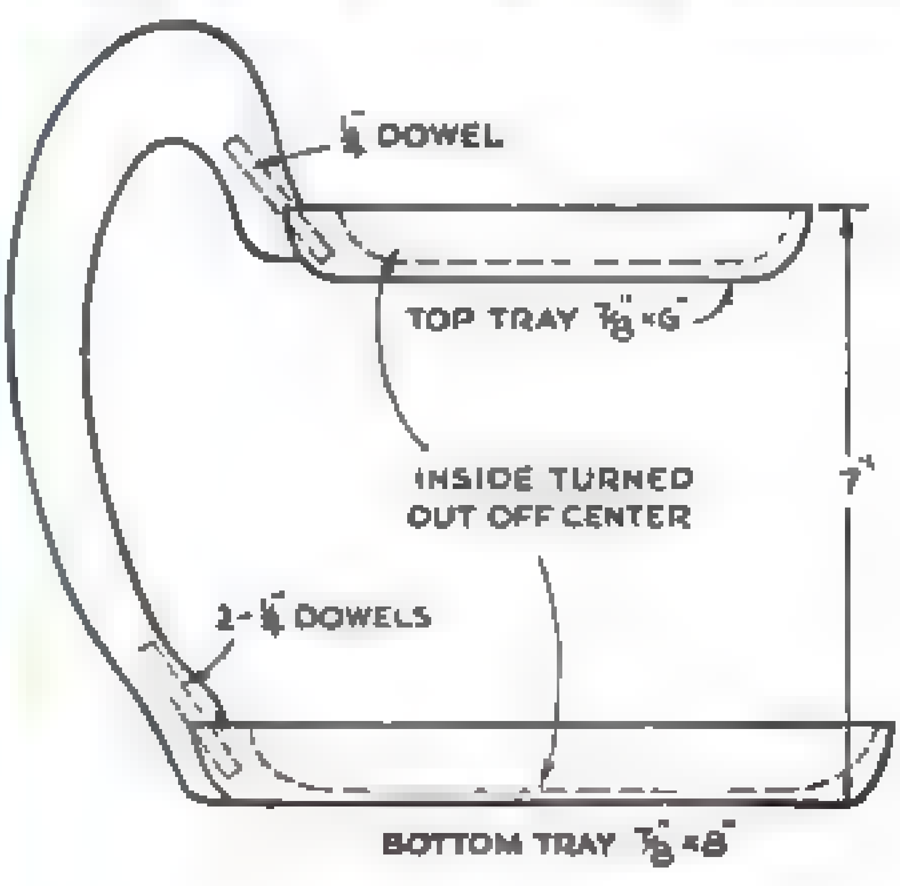
IF LATHE and band saw are available, the amateur woodworker can turn out this two-tier tray with a minimum of effort. The result should completely justify a couple of evenings spent in the workshop.

Start construction with two walnut disks of ⅞" stock, one 6" and the other 8" in diameter. Glue these to pieces of waste stock. Mount one disk in the lathe ¼" off center, with the waste stock towards the faceplate, and turn out the inside and top edge as indicated in the drawing. Sand thoroughly and shellac while it is in the lathe. To complete the finish, run the lathe at low speed and hold against the work a cloth moistened with a little alcohol.

Remove the work from the faceplate and remount on centers to turn and finish the outside edge. Separate the tray from the waste stock, sand the bottom, and apply a coat of shellac. Turn and finish the second disk in the same manner.

Cut a block for the handle from 1½" stock. Make a saw cut for the strengthening inlay. Prepare a maple insert with the grain running opposite to that in the handle and glue it into the cut. Band-saw the handle to shape, as shown in a photograph on the facing page, and then round the edges.

Attach the handle by doweling it to the widest sections of the tray edges. Finish the handle with several coats of shellac, rubbing down well between coats. Glue a piece of felt to the bottom of the lower tray to protect table tops.—BENJAMIN NIELSEN.



Trays for the two-tier tidbit server on the facing page are mounted off center, turned, and finished in the lathe

Band-sawing a side of the handle to shape, as shown in the drawings on the opposite page

Streamlined Candelabra

TWO streamlined double candleholders cut from a single 8" disk of wood make an unusual gift and one easy to pack for mailing. They are so stout that the parts need not be glued, therefore they can be readily taken apart. The pair will be welcome ornaments for use on a table or mantel as small candelabra.

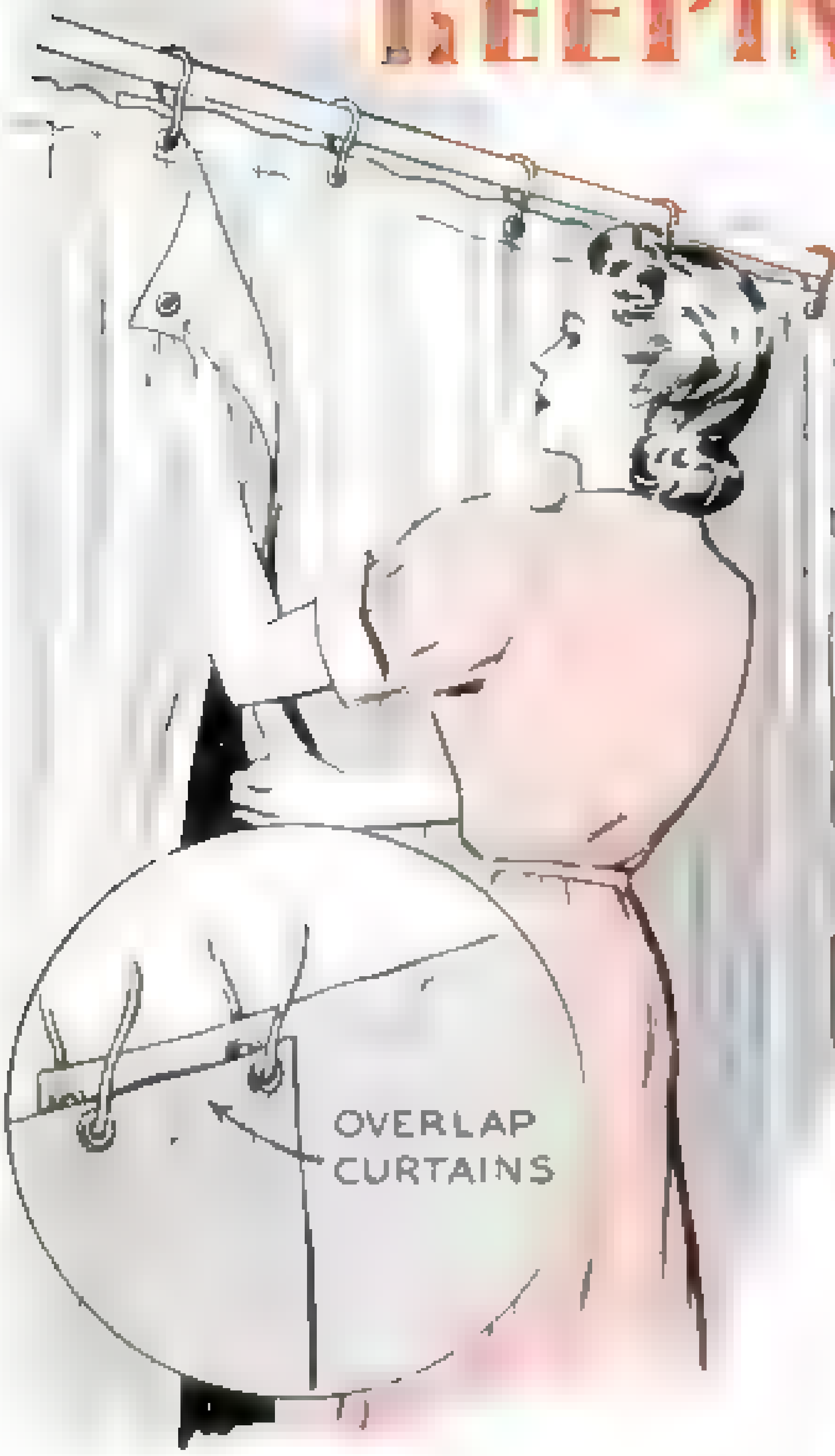
The disk is mounted on the faceplate of the lathe. Holes in the base may be eliminated by gluing waste stock to both sides. One side is turned as shown in the drawing; then the disk is remounted, and the other side turned to complete the ring, after which it is sanded and turned off.

The ring is next cut in two equal sections, and a hole is bored in the center of the bottom of each. A 5/8" bit is used to begin holes for the candles, and a slightly smaller bit for finishing them. The wood remaining in the lathe is parted through the center, each piece still attached to its waste-stock backing. Then the portion remaining on the faceplate is turned concave, leaving an oversize tenon in the center. The edge is finally shaped as shown in the photographs below. This entire base is sanded, shellacked, and turned off the waste stock. The process is repeated for the other base. Working time for craftsmen, 2 hours; for beginners, 3 hours.—B. N.

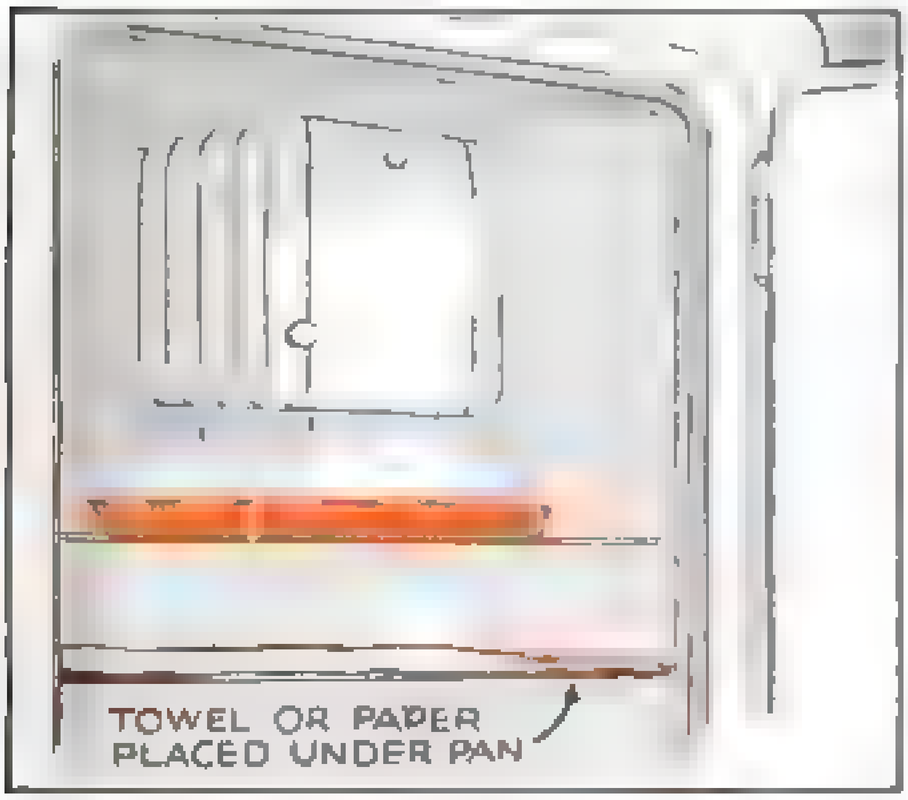
Taken apart, the candleholders and bases are readily packed

Ring and base fit so snugly that gluing is unnecessary

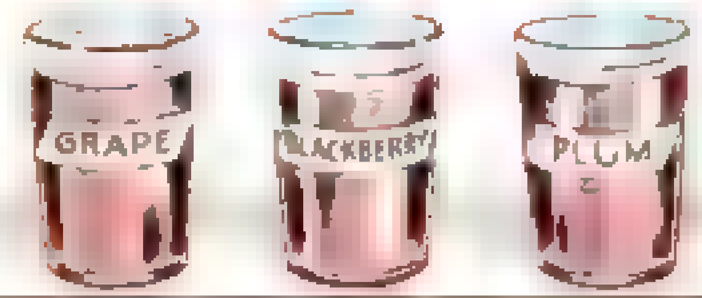
KEEPING THE HOME



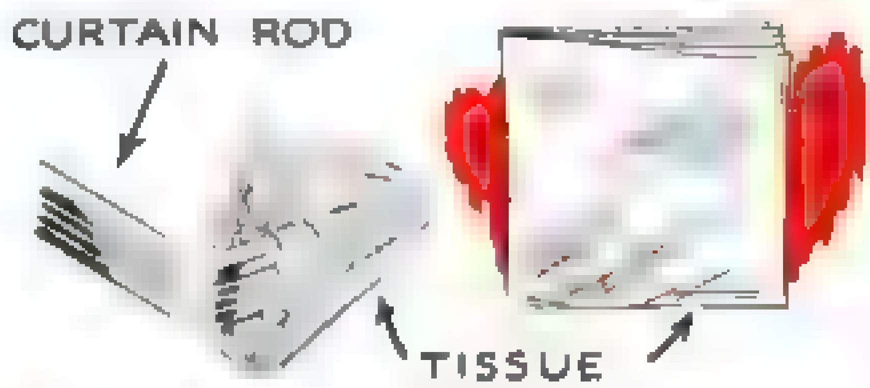
When shower curtains are hung in pairs, overlap the adjoining edges by using the second hook of each curtain to support the corner eyelet of the other. This prevents leakage between the edges



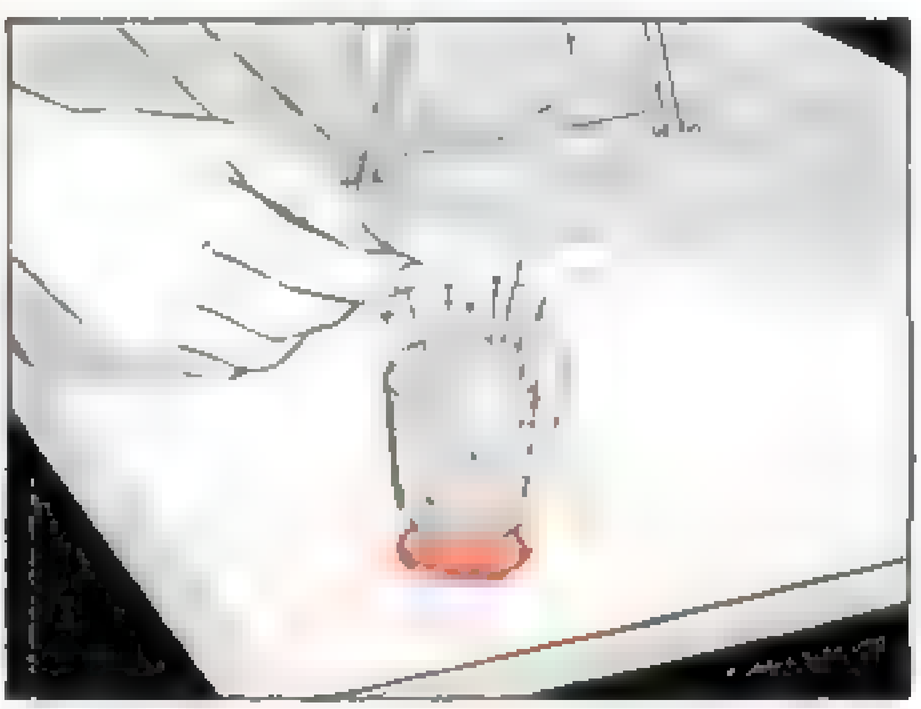
Cloth or paper towels below the refrigerator tray will catch stray water during defrosting. Remove them when finished, as they hinder circulation



Convenient labels for preserve jars and food cans—either glass or metal—are made from narrow adhesive tape lettered with waterproof ink. The tape sticks better than gummed paper



Tissue paper, folded twice and pressed smoothly over the end of a metal curtain rod, will keep sharp corners from catching when the rod is being pushed through a hem, especially of net material

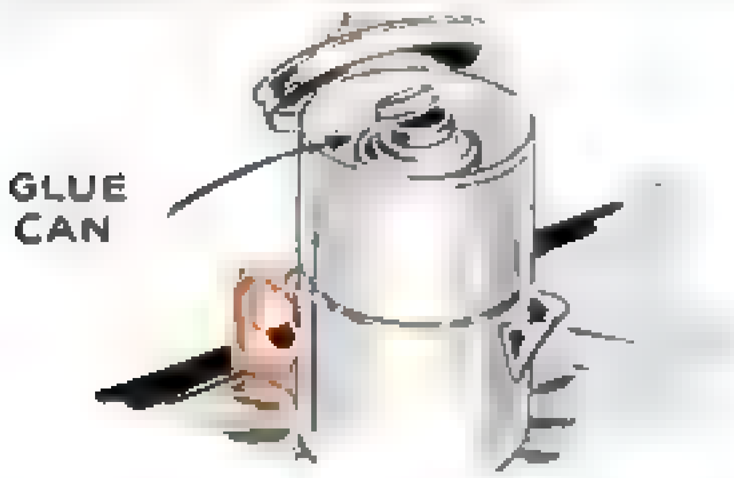


A pincushion that "stays put" on a sewing machine can be made by screwing a large cork to a suction cup. Glycerin rubbed into the cup helps its grip

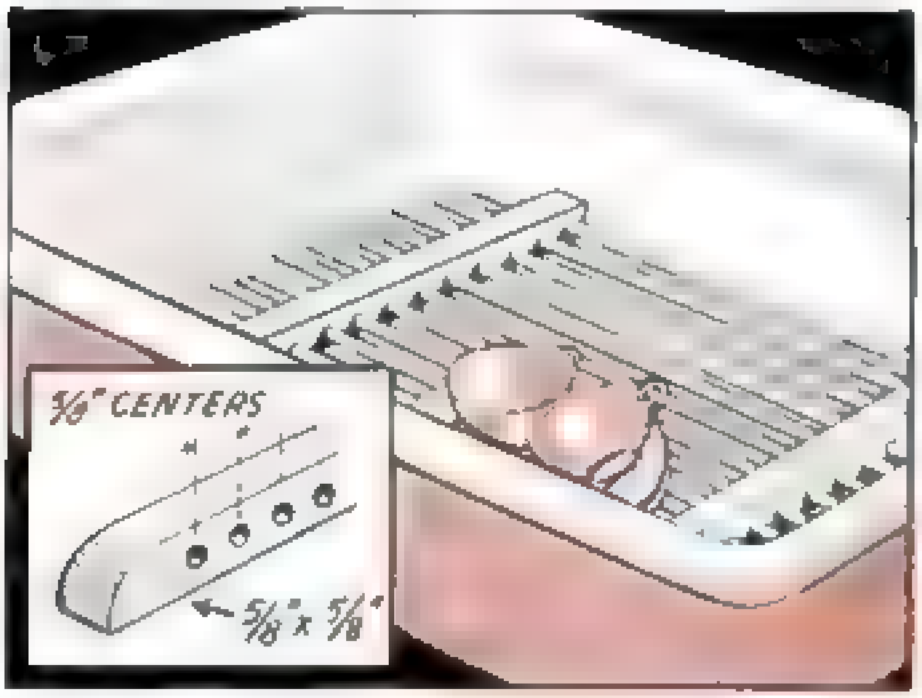
If measuring spoons in a set slip off their ring, hang them on a poultry marker. These bands are large enough to allow play in handling the spoons

SHIPSHAPE

Short nails, tacks, or screws with rubber or felt heads act as bumpers if attached to the back of drawers that slide in too far. The padding on the heads can be trimmed down if it is too thick



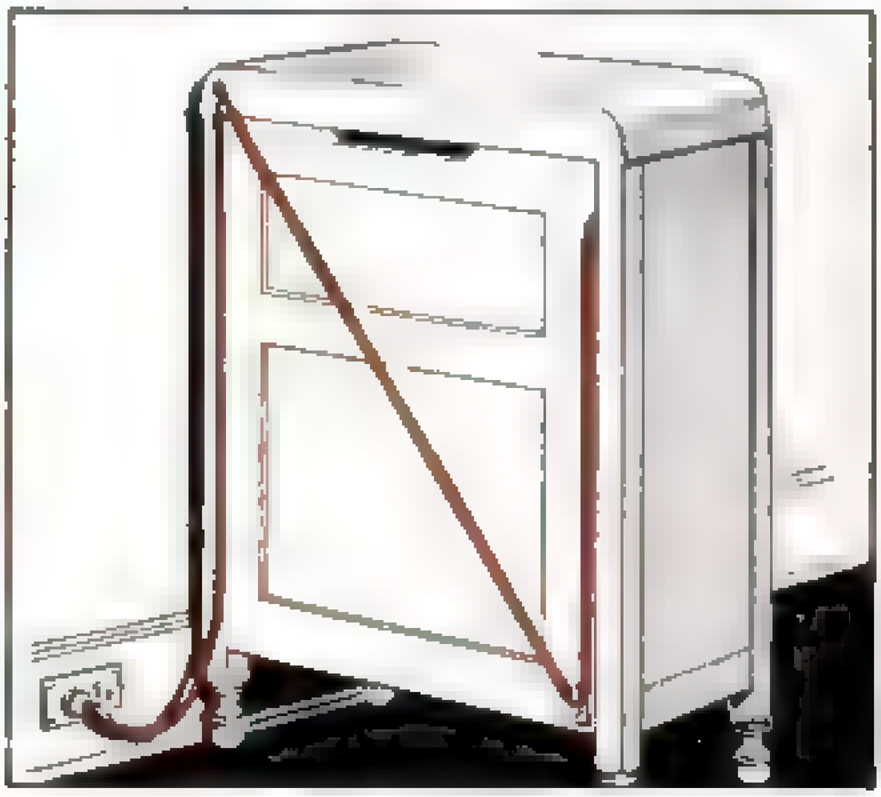
An old drip-type coffee maker no longer used for its original purpose can be put to new service as a glue heater. Set the glue pot in the top part, and steam by boiling water under it in the bottom



Well-sanded dowels fitted into two wooden rails, cut to dimensions and bored as shown, form a mat for the bottom of a sink. No glue is necessary

Edging for a sink shelf in a darkroom or camp can be made by bending the edges of flat curtain rods to encase the ends of the linoleum shelf covering

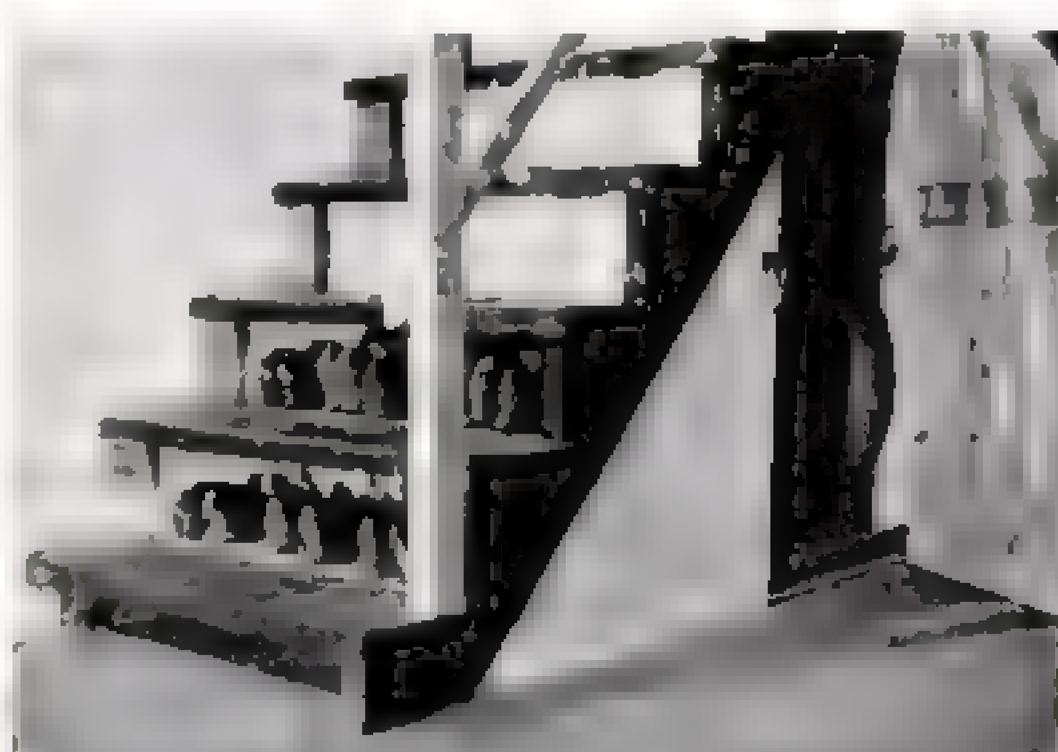
Thin copper wire strung on rustproof nails driven into the top of shutters will discourage roosting by birds and will not be visible to passers-by



Surplus electric cord may be concealed by hanging it on picture hooks attached to the back of the radio or of a dressing table where a lamp is used

At the right, the closet is shown complete, except for the doors to the shelf space which, however, may be omitted, if desired. Below, closet siding and plywood panel in place, ready for shelves and doors. All available space is utilized

Below at left a rear view of the lowest steps, the treads of which are extended back to form shelves for storing rubbers and overshoes. Below at right, the same steps from the front. Note the opening into the tire-storage compartment, and the batten door, only part of which is visible. This cupboard can, of course, be used for holding rubber hose, garden implements or other equipment. The space may be divided as necessary to suit special needs



Understairs Closet

PROVIDES EXTRA STORAGE SPACE IN CELLAR

A CLOSET, built into waste space under the cellar stairs, is ideal for the storage of rubber garden hose and other noncombustible articles that should be kept in a cool, dark place, as well as canned goods and preserves. Such a closet may be locked if desired and, far from taking away useful space, eliminates an unsightly, dust-catching corner.

First of all, the vertical spaces between the steps were filled with risers, fitted between the stringers and nailed to vertical blocks behind. Filler pieces were used to close the gaps between one stringer and the adjacent cellar wall. Admittedly, it is easier to nail boards across in front of the treads, but unless the latter are fairly deep, doing so may make them too narrow for a safe footing.

The two lowest spaces were not filled with risers. Instead, shelves were built in behind the treads, level with them, in order to accommodate the family rubbers. This, however, is an added feature, which is not recommended if children are likely to put their rubbers away carelessly, and perhaps leave one lying exposed on the stair tread for someone to trip over. Anything left on stairs represents a hazard and may cause a bad tumble, especially if the light is poor.

A base of 2" by 3" pieces was laid for the closet, and a scrap of 1" by 1" stock was nailed to the underside of the outer stringer to form a rabbet for the closet wall. Beaded 1" by 8" tongue-and-groove stock was used for the latter. The pieces were butted against the baseboard and cut at a slant to fit against the stringer above.

Three of these boards, fastened together with battens, formed the door. The uppermost batten was placed parallel with the top of the door. The projecting tongue on the hinge side and one interfering wall of the groove on the latch side of the door were removed.

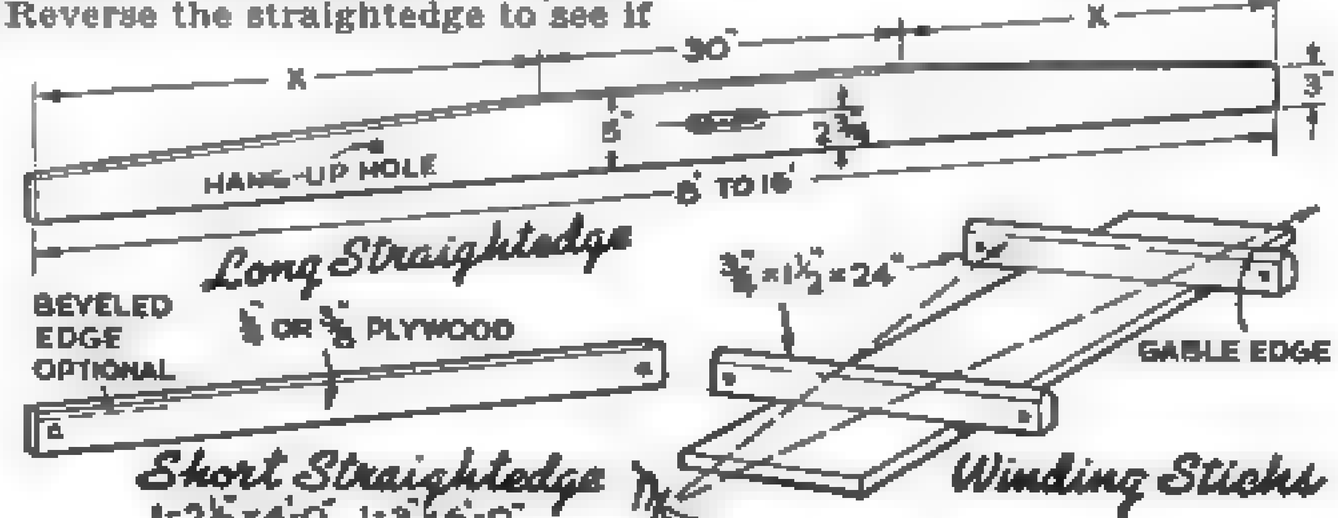
Extra shelves may be nailed up inside the closet or against the outside of the plywood rear wall, as shown in an accompanying photograph.

The following material was required for the closet shown: 16' of 2" by 3" lumber; 60' of 1" by 8" tongue-and-groove stock; 26' of 1" by 8" lumber for risers; 24' of 1" by 12" pine for shelves, and one 3' by 6' panel of 1/8" plywood, as well as hinges, a latch, and paint. The cost of No. 2 common grade lumber in Huntington, Long Island, was about $8—STUART EVAN.

WOODEN STRAIGHTEDGES [WOODWORKING]

Select straight-grained white pine for long straightedges. True one edge, gauge the width, and rough-taper the back. Apply three coats of spar varnish for waterproofing. Hang up for a few days to allow any warping to occur, then straighten again. Lay the straightedge on the floor and draw a fine pencil line. Reverse the straightedge to see if edge matches, and correct accordingly.

Three-ply stock is suitable for shorter straightedges. These also should be seasoned for a time before final straightening. "Winding strips" to lay on the ends of boards and sight across for wind can be made from any scraps.



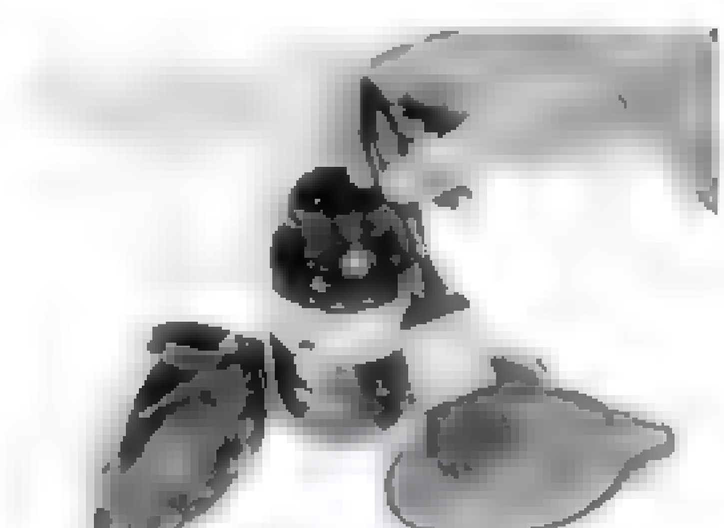
Housekeeping Aids

YARN SPINS AROUND WITHOUT TANGLING on this wrist holder as the knitting needles take it off its ball, saving time lost in picking up and rewinding a dropped ball. The wrist band pivots on a spike that impales the yarn ball, permitting yarn to be drawn from the outside as the ball turns automatically. A disk is attached at the sharpened end of the stake after the yarn is in place, and keeps the ball from slipping off while it is being used. As an added convenience the holder is marked off as a 4" rule to give the knitter a handy standard for measurement of stitches and the like

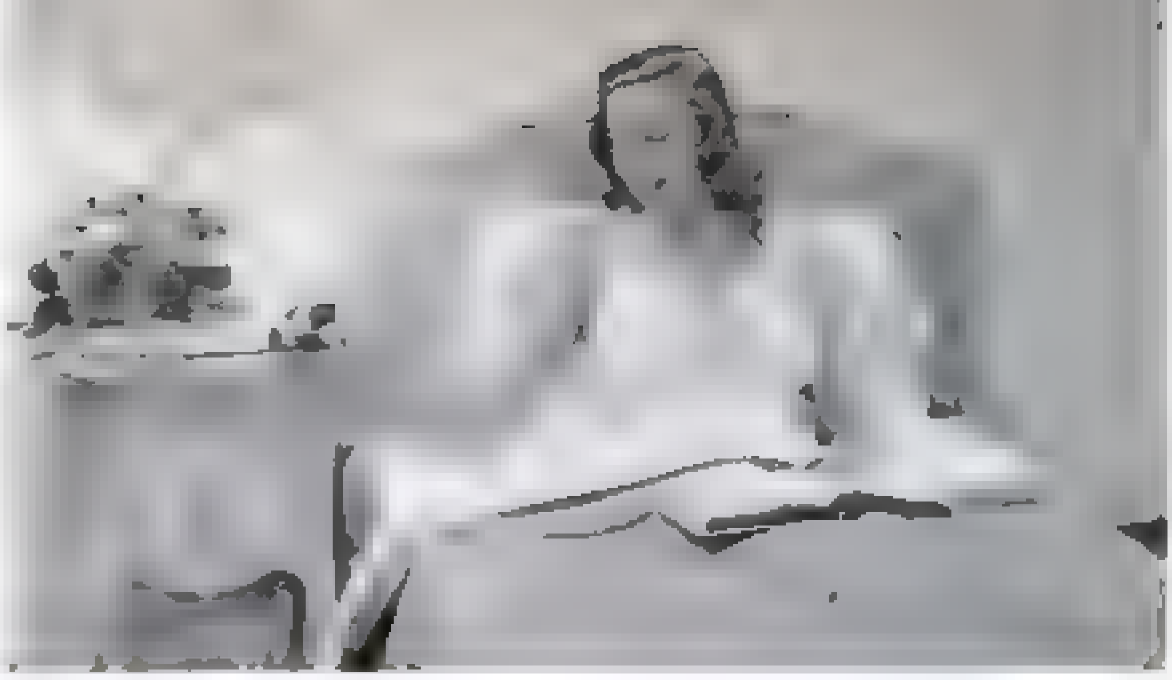
FROZEN CANAPÉ ROLLS will keep fresh indefinitely in the freezing compartment of a refrigerator, and can be quickly served simply by slicing and using cold or heating briefly if desired. The rolls are really rolled sandwiches stuffed with a choice of ten fillings including liver patty, turkey, salmon, hams, cheeses, and combinations. The rolls are only 5" long and 1½" in diameter, but if sliced while still cold and firm will make as many as 18 thin, dainty canapés. Some of the rolls have paprika spread on the outside, adding a bright touch of red coloring to these delicacies. If the sandwiches are to be toasted, grated cheese sprinkled on those containing meats gives added zest

CARVING-KNIFE SHARPENER AND CASE are built into one unit in the useful and attractive carving-knife and holder set shown in the photo below. The sharpening stone is imbedded in the base of the case, which is made of wood and provides a firm and adequate grip when honing. The knife itself has a 9" hollow-ground blade, long enough for slicing through a large roast, and a 5" handle of a plastic material resembling wood. Two large riveted studs hold the handle and blade securely

CRACKED RUBBER IS SEALED and given longer life with a coating of a flexible, black synthetic that has recently been developed. Deterioration of the walls of automobile tires, garden hose, overshoes, mats, and other articles of rubber can be retarded by the coating, which protects the surface from sun, water, dirt, oil, and gasoline, and always remains elastic



ELECTRIC BLANKETS, controlled by thermostat to maintain constant warmth regardless of any change in temperature during the night, save home fuel. The element consists of fine, flexible wires woven inside the fabric. A small transformer in the circuit reduces standard alternating current to 15 volts. Operation simply requires setting a thermostat dial and plugging in. The quantity of blankets available is limited since the factory has turned to production for the Army



Getting More Service from a Vacuum Cleaner

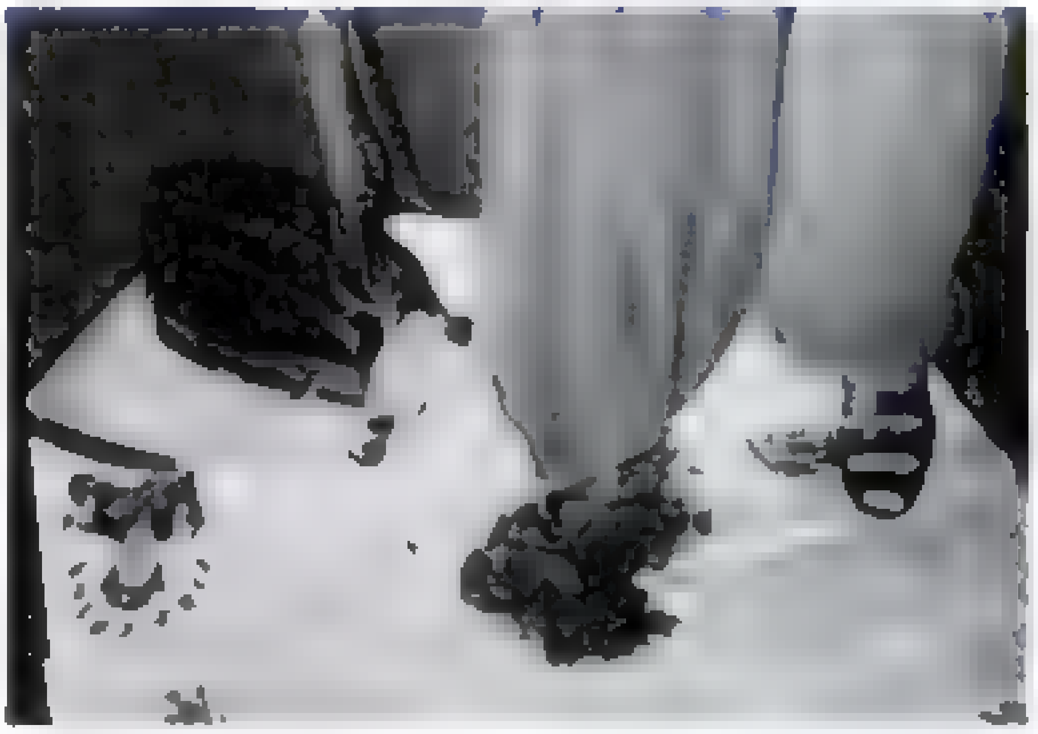
MODERN vacuum cleaners have a multitude of attachments, each of which makes some job easier. Use them often. Then follow these four rules for efficiency:

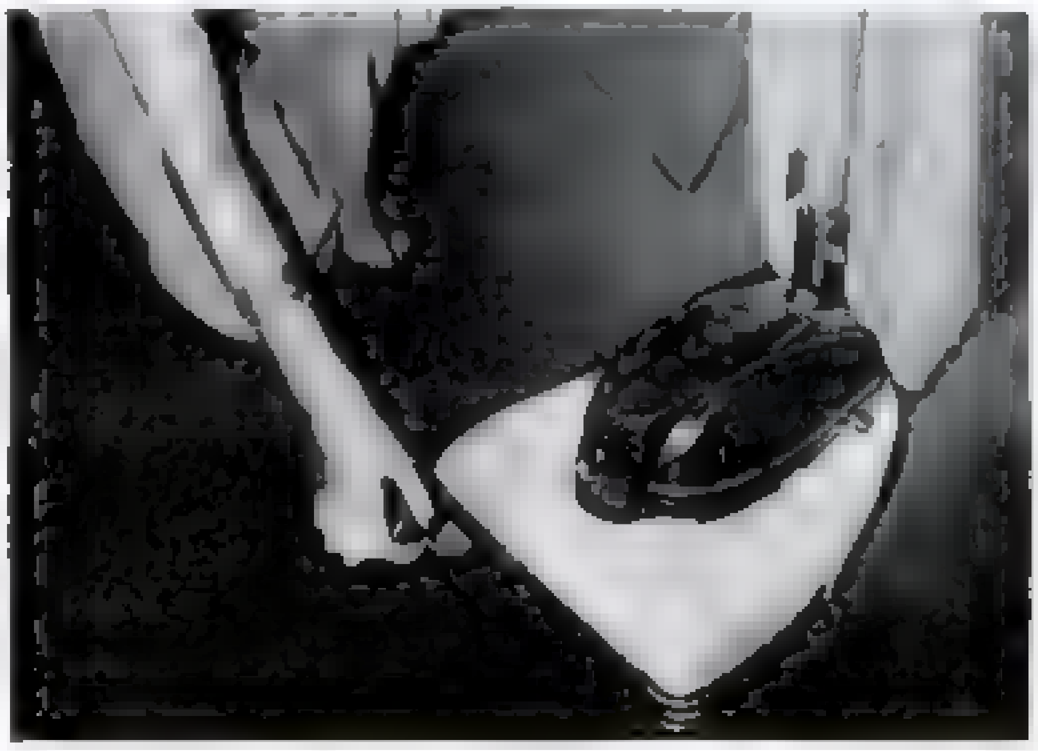
Empty the bag every time it is used; dirt cuts down effectiveness. Never wash the bag, but clean it occasionally by beating or brushing. If it is very soiled, replace it.

Never jerk on the cord to remove it from a socket. The strain may eventually pull it from the plug. When putting the cleaner away, wind the cord loosely around the hooks on the handle.

Avoid tacks, pins, and other sharp metallic objects that may cut the belt, puncture the bag, or do other damage.

The intake nozzle should clear a rug by the thickness of a half dollar so that suction can raise the pile and open the nap. Check the adjustment once in a while.





Question Bee

PRECISION measuring tools were a late product of the machine age. It was not until 1848 that the prototype of today's micrometer was patented in France. Early calipers, employed chiefly in wood turning, were constructed of wood and evolved from the compass first used by the Romans. The forerunner of the modern rule was homemade.

Below are illustrated eight measuring tools widely used today. Try to identify them all and write their names on the dotted lines. The answers are printed upside down below.

1 ....

2 ....

3 ....

4 ....

5 ....

6 ....

7 ....

8 ....

ANSWERS

1. Universal surface gauge
2. Micrometer caliper
3. Universal bevel protractor
4. Combination square with protractor head
5. Slide caliper rule
6. Outside spring calipers
7. Thickness or "feeler" gauge
8. Wire gauge

IMPROVED

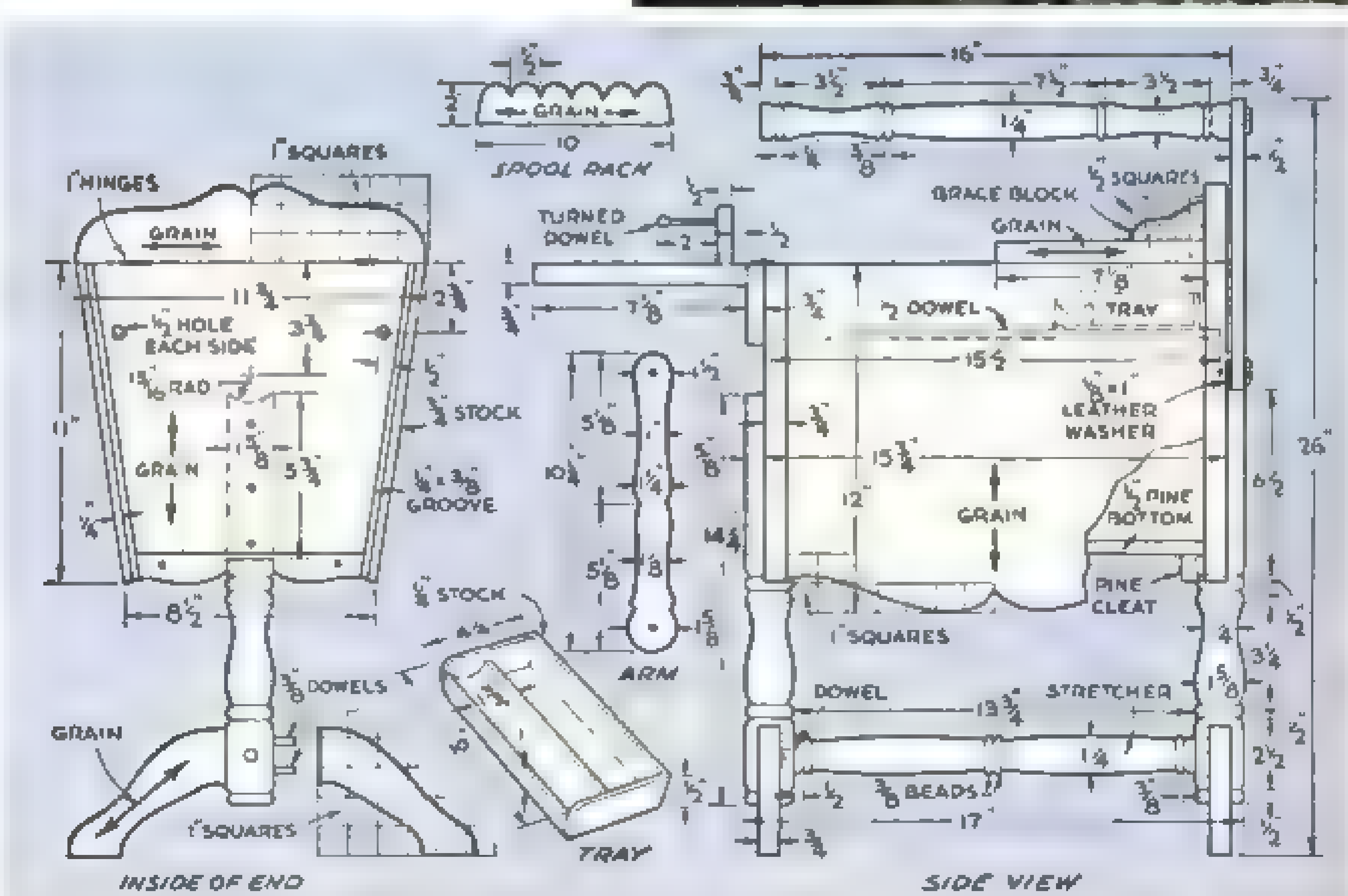
Sewing Cabinet

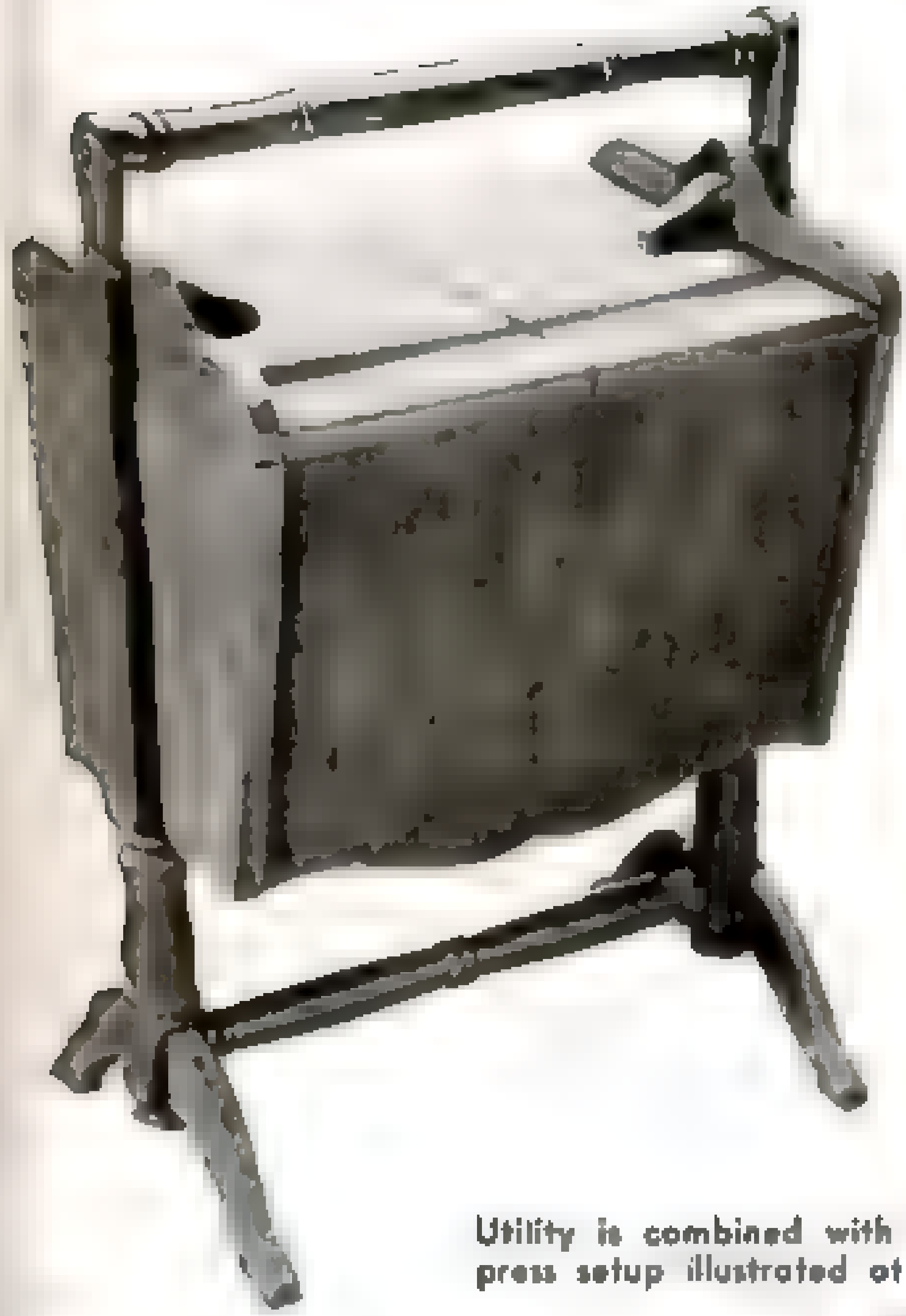
OPENS WIDE TO GIVE EASY ACCESS TO CONTENTS

By Frank Hegemeyer

KNITTING and sewing have again become so popular that a cabinet for holding the necessary materials and accessories will be welcome in almost any household.

The modified Priscilla sewing cabinet shown here is patterned after an early American design, but is fitted with a pivoted handle so that the two lids can be opened out toward the ends to form leaves for holding materials. This gives easy access to the





Utility is combined with attractive appearance in this sewing cabinet. The drill-press setup illustrated at the right is excellent for boring dowel holes in the feet

contents of the cabinet, and the handle, when lowered, forms a rack that also can be used to hold material. A small sliding tray is provided for spools of thread, pins, needles, and other small accessories, and there is a spool rack on the inside of one lid. Half loops for scissors, knitting needles, and the like inside the cabinet can be made of a short length of ½" wide leather fastened at intervals to one of the ends.

Of the many fine woods available for the purpose, walnut or mahogany, which warp and shrink very little, will be the choice of many workers. American black walnut was used in the original cabinet.

To minimize warping, glue up the stock for the lids and ends of three 4" wide boards with heart and sap sides alternating. The direction of grain for the best effect is indicated in the drawings.

Cut the grooves for the plywood sides in the endpieces and attach a cleat to the inner side of each as shown. Sand the ends and feet smooth before gluing them to the turned legs.

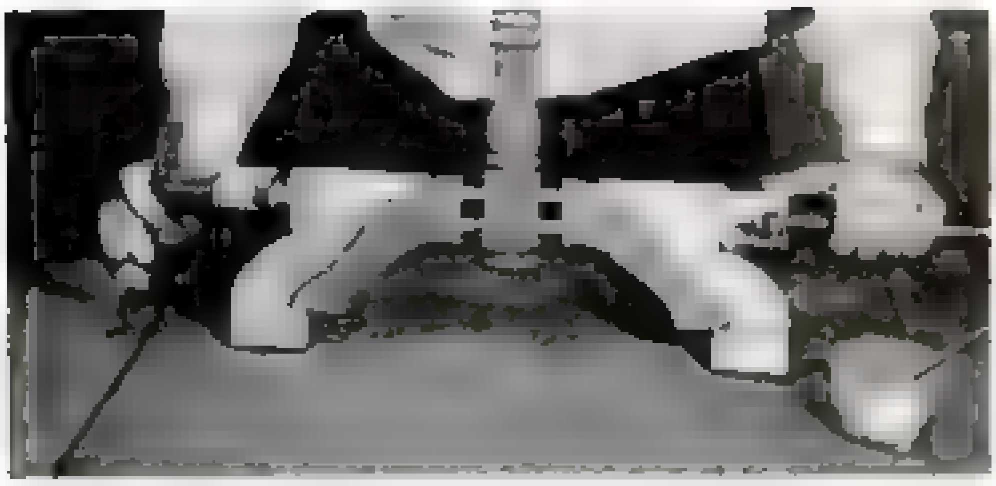
Bore ½" holes ⅝" deep in the ends and legs to receive the long inside dowels and the stretcher. Use a Forstner or similar bit that will not pierce the ends. Assemble by gluing in the dowels and screwing the pine bottom fast to the cleats as shown in the photographs. The dowels serve as slides for the tray.

Apply glue to the ends of the handle. Screw the arms to the handle and to the cabinet, inserting leather washers where the arms pivot. Brush a thin coat of glue in the grooves before sliding in the plywood sides.

Dowel and glue the brace blocks to the lids before similarly fitting on the scroll-sawed tops as shown in another of the photographs. Hinge the lids to the ends. Fasten the spool rack to the lid with ¼" dowels.

The tray ends slope at the same angle as the sides. To make the cove cut for the pin tray, set the circular-saw blade ½" above the table and clamp a guide strip ¼" from the far end of the blade. Clamp the other end to hold the strip at an angle of 18 deg. to the blade. Lower the blade to project only 1/16" and make a series of 1/16" deep cuts, feeding the work slowly, until a depth of ½" is attained.

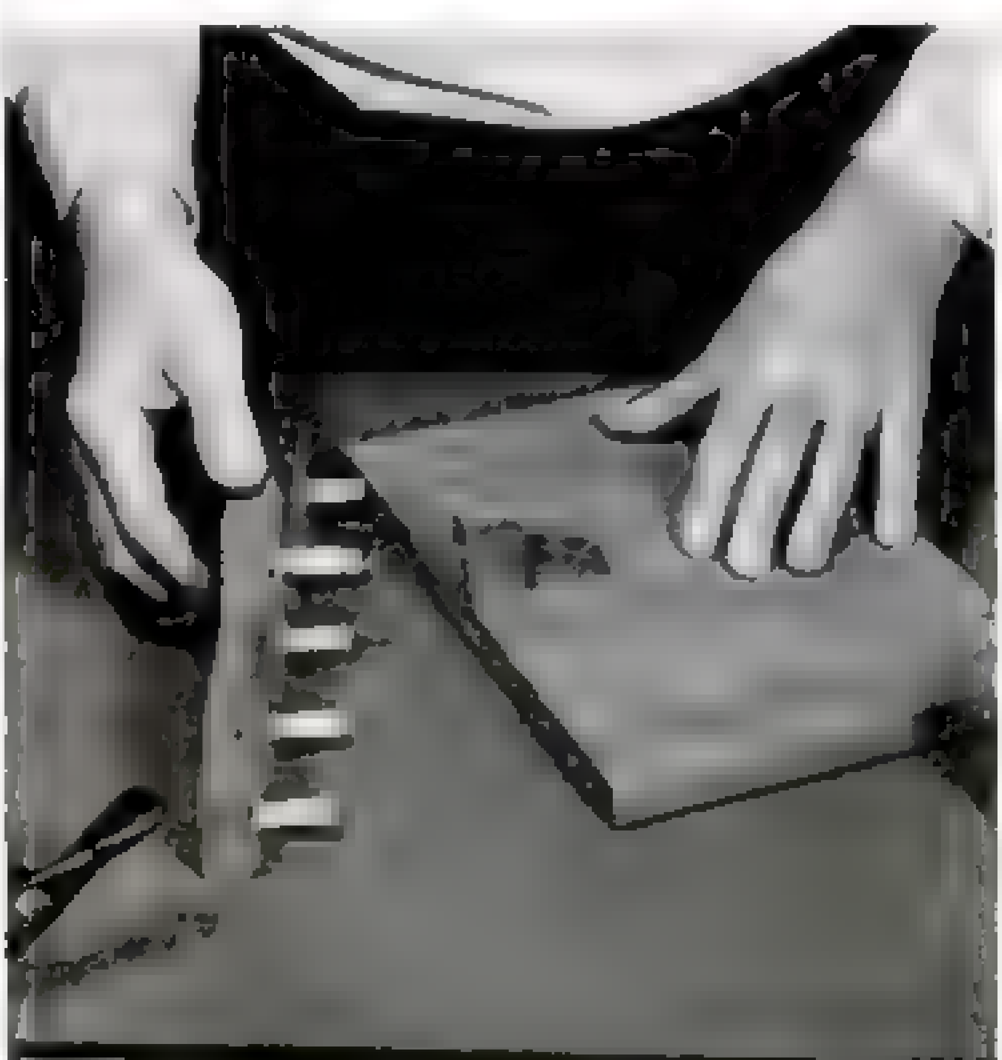
Finish by staining, filling, and lacquering or varnishing in the usual way, according to preference. To enhance the beauty of the project, apply medium-blue enamel to the inside, including the tray.



Two blocks cut from ¾" plywood to fit over the feet, as above, make an efficient clamping jig

A small amount of glue applied to the grooves in the two ends is sufficient to hold the sides

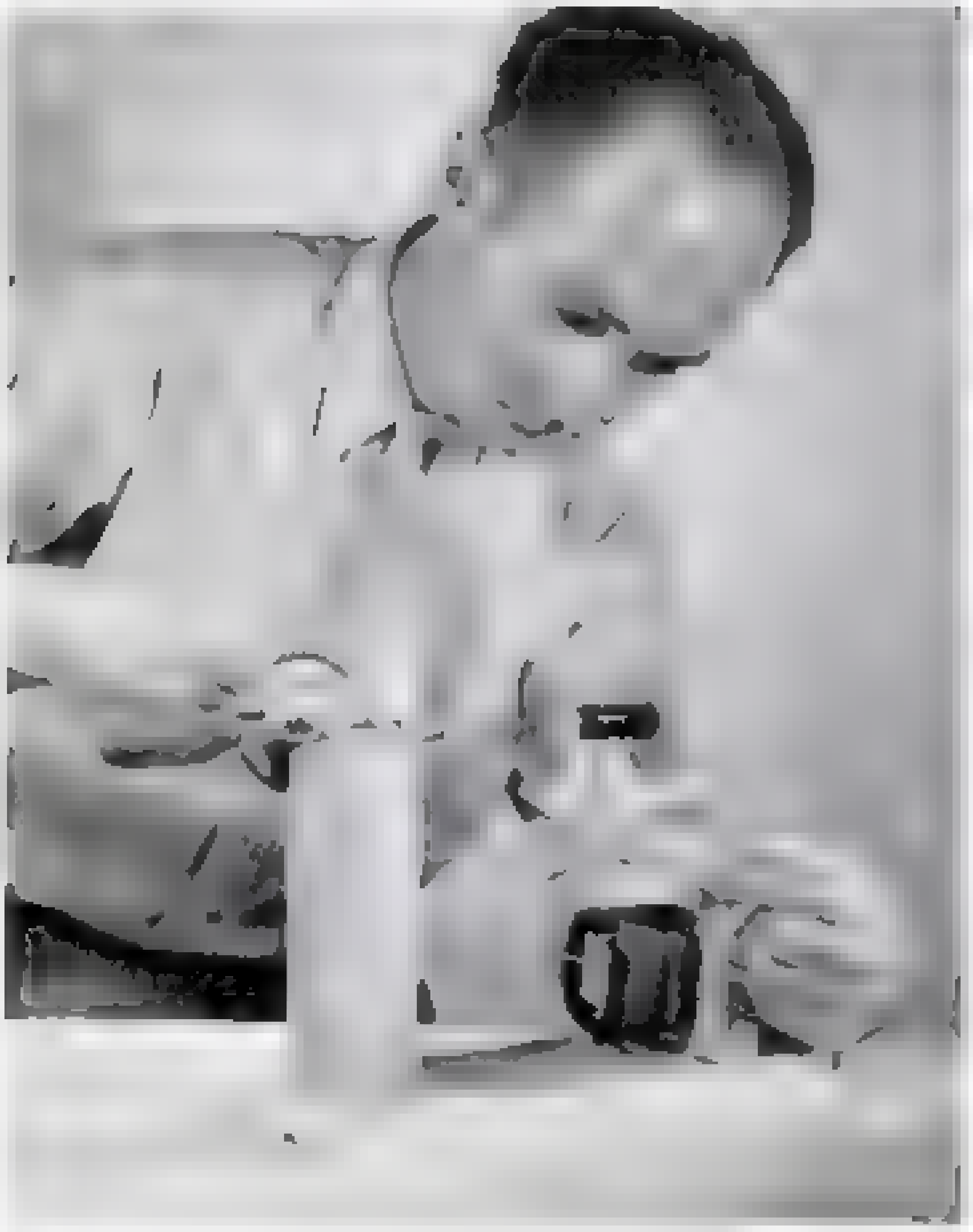
Common pine is used for the cleats and bottom, which are well fastened with glue and screws



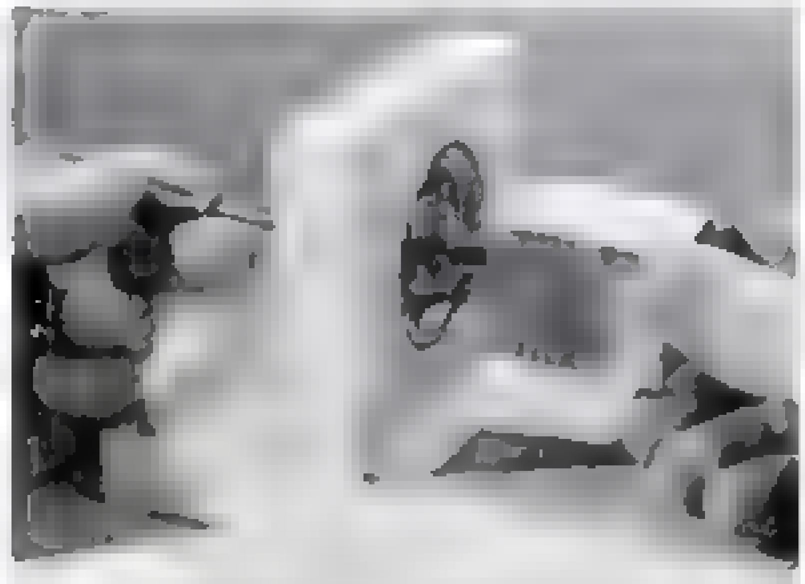
Attaching a scroll-sawed end to a lid. The dowel holes were marked to coincide by using small brads

The spool-tray cove was shaped gradually on the circular saw by raising the blade 1/16" at a time

Salvaging Copper Wire



Respooling equipment for salvaging wire is made simply. An egg beater can be adapted to serve as a spool holder



For a coil bearing, use a roller-skate wheel fitted into an upright and bolted to a block

By KENNETH MURRAY

HUNDREDS of tons of pure copper wire, much of it good enough for reuse, is available practically for the asking. There is an even larger amount of expensive, special-type steel that can be recovered and salvaged by the wide-awake amateur.

Both are found in discarded radio coils and transformers. For the past 20 years, as radio developed, obsolete models and old parts were discarded to accumulate in the serviceman's junk pile. Some parts were still good but out of date; others were burned out or otherwise damaged. Regardless of their condition, all the copper in them can be recovered. If the wire is badly burned, it can be remelted for use. Much of it will be found in perfect condition and will require only careful unwinding and respooling to be available again for a multitude of purposes.

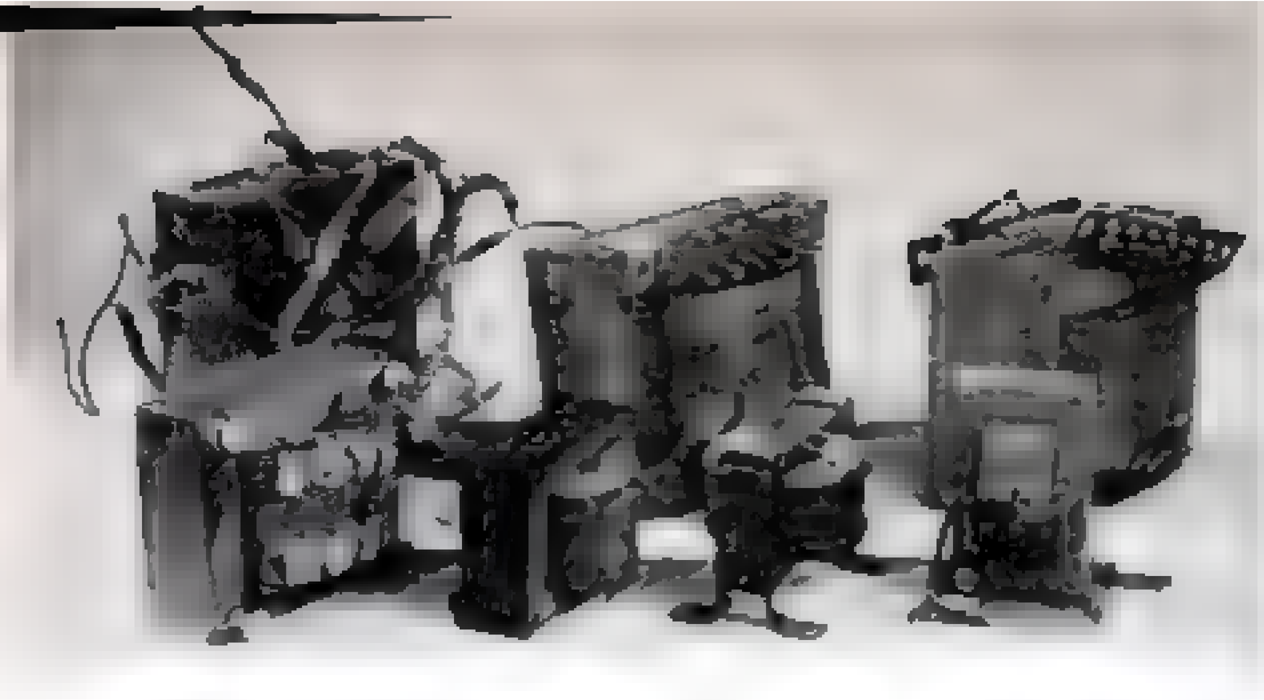
The silicon-steel cores of old transformers are as good as new. Already cut in standard shapes, they can be rewound to make new transformers or melted down for their metal. Only the co-operation of owners of such junked parts and amateurs or others with spare time to salvage the materials is necessary to make this valuable copper and steel available in quantity.

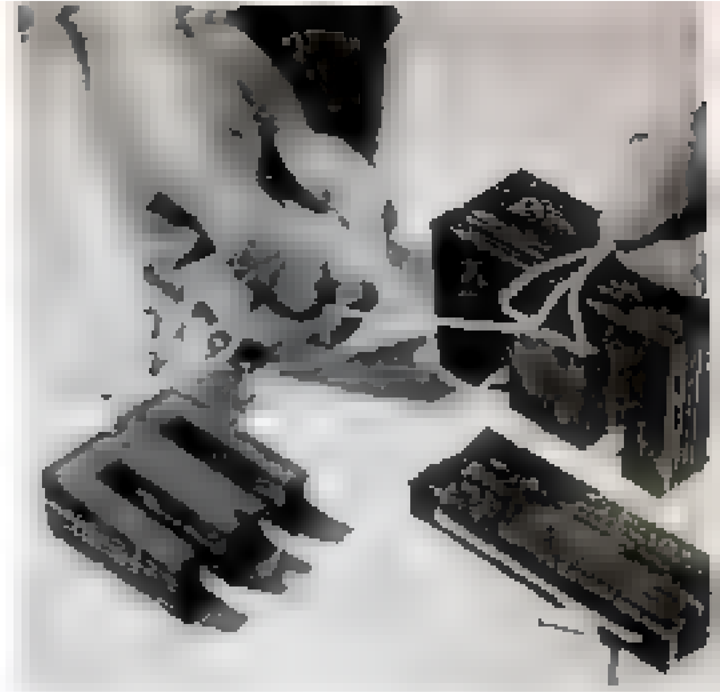
Each transformer may contain up to a pound, and sometimes more, of copper wire. Often a full ½-lb. spool of it in practically new condition can be recovered from one coil. Worth a dollar a pound or more, its real value to our war industry cannot be measured in dollars and cents.

Salvaging burned coils. When heat has charred the insulation of a coil, it is best salvaged for its copper. If the wire is small, the remainder of the insulation can be burned off with a blowtorch or in a furnace. The wire can then be pressed into flat cakes for remelting. Wind larger wire over dowels set about 12" apart. The hanks so formed can be twisted tight to take less space for shipment. Never wind the wire into a loose mass; it is then too bulky for economical transportation to salvaging plants, and there is more loss of metal through oxidation when it is melted.

Dismantling transformer cores. Remove the core bolts or rivets (which can be sorted and saved) and unstack the laminations one at a time. A nail set may be required to loosen the first few, or it may be necessary to flow alcohol over the edges to soften shellac. Tie the laminations together; don't mix different sizes and shapes.

Respooling wire. Spools can be made from wood dowels and plywood disks. If you do not have a small lathe for rewinding the wire, a homemade winder can be assembled cheaply as shown in the accompanying photographs. It consists of a wood base and





Copper wire can be salvaged from millions of old transformers and coils in the radio servicemen's junk piles. The cores of special steel should be tied with string, as at right, for reclamation

an upright into which a roller-skate wheel fits tightly. This serves as a bearing for the coil to be unwound. To the wheel is bolted a wood block that fits snugly inside the coil. The geared spool holder is made by cutting down an egg beater so that the wings form a spring clip that will grip one end of the spool—if the beater is of the double-action type, remove one shaft. This holder is then screwed to an upright at the end of the base opposite the coil bearing. Drill through a short piece of dowel, file or sand it flat on two sides, and fasten it with wire between the beater arms. The spool to be wound has a hole drilled through to fit this axle.

A cleaner consisting of a spring clothespin with a bit of cloth between the jaws will remove particles of insulating paper from the wire as it unreels. Do not use steel wool or sandpaper, for either might damage the insulation.

Many coils of fine wire are impregnated with paraffin; they should be kept warm with an electric bowl heater so that the wire will unreel freely.

Small spools of wire are handy for experimental purposes, but for salvage on a large scale it is better to utilize spools holding three, five, or more pounds. Only one size of wire should be wound on a spool. Splices should be neatly soldered, coated with insulating varnish, and marked with bits of gummed paper or tape so that they can be located as the wire is unreeled. The wire need not be wound in perfectly even layers, but only as evenly as is consistent with speed in winding.

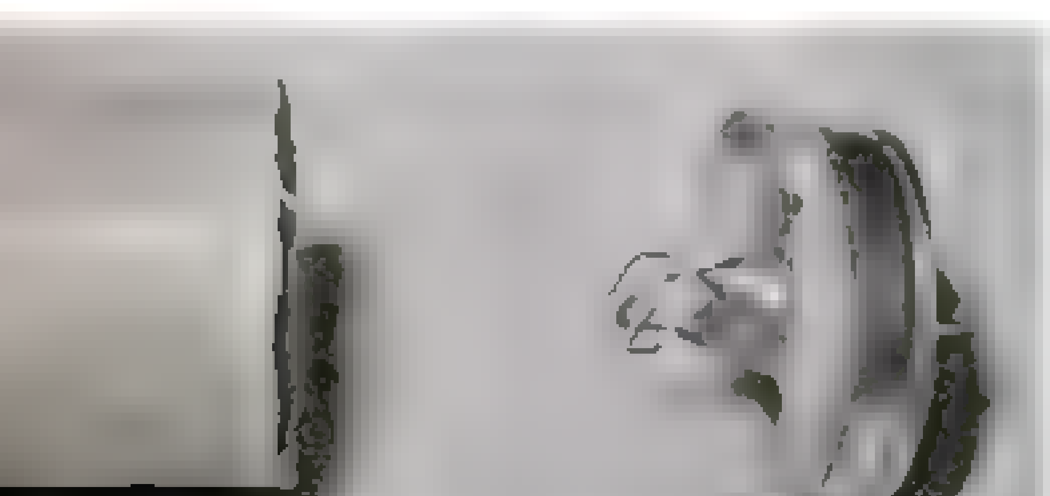
These suggestions will enable anyone to start recovering this valuable material. Wire to be salvaged for its copper may be turned in at the usual collection stations or sold to scrap dealers. Wire that is in good condition and spooled can be sold at higher prices to dealers and also to manufacturers of electrical equipment or to motor rewinding and repair shops.

Damaged wire to be melted is coiled on dowels, removed, and twisted into solid hanks that pack well. Bunched wire, as at left, is unsuitable

Winding is fast on a metal- or wood-turning lathe. Small spools are convenient if the wire is for home use, large ones more practicable for salvage

When Fluorescent Lamps

Simple tests reveal faulty equipment. Here a manual switch is being used to check the starter and ballast



What the end of a fluorescent tube looks like inside. The filament, preheated by the starting current, emits electrons that strike the arc the length of the tube

THE magic of fluorescent lamps has given thousands of us, in factories, stores, and homes, a new conception of artificial daylight. Like most electrical and mechanical devices, however, fluorescent fixtures require a certain amount of servicing if they are to continue to perform in a satisfactory manner.

The lamps are rated at 2,500 hours of useful life, but this may be shortened considerably if they are turned on and off too frequently or if they are used with poorly designed or defective auxiliary equipment. On the other hand, lamps which are left in service after their useful life is over, and which are therefore hard to start, place overloads on the ballasts and starters that may eventually ruin these units.

When a lamp is started, a current flows through the filament electrodes at each end of the tube. This preheating current lasts until the starter contacts automatically open, at which instant a surge in voltage due to the presence of the reactor ballast in the line occurs. This is sufficient to set up an arc stream from one electrode to the other through the vaporized mercury in the tube.

The electrodes are coated with a special material, which when heated emits great numbers of electrons. These carry the current that creates and maintains the arc. Constant starting, with the resulting voltage surges, cause a premature wasting away of this material. Such abused lamps will not burn for their full rated life, for when electron emission is no longer abundant the lamps are hard to start or will not start at all.

The light of fluorescent tubes is not

An old starter button forms the terminal of a manual starter, which is used for trouble shooting fixtures as in the photograph above

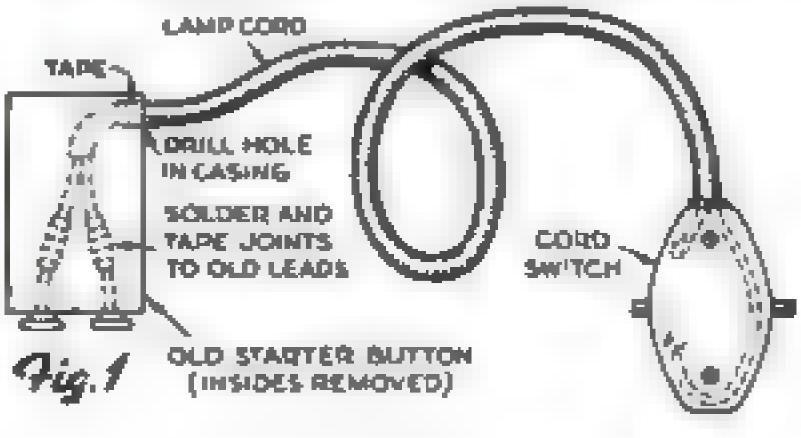


Fig. 1

Go Wrong

By HAROLD P. STRAND

from the arc stream as one might suppose. The inside of the glass is coated with substances that glow or fluoresce under the ultraviolet radiations of the arc, thus emitting the brilliant light we see.

Let us assume a lamp does not light when the control switch is closed. The first and simplest check is to make sure that the current is on at the fixture. The second is to remove the tube and try it in another fixture or other sockets of the same fixture in which a tube is operating correctly. If the lamp lights readily there, the trouble must be in the auxiliary equipment, and the next step is to replace the starter with a dummy or manual starter.

Details for making such a starter are given in Fig. 1, and the photograph at the top of the facing page shows it being used for testing a fixture. To start the lamp, push the "on" button, which should cause the ends of the tube to glow. After a few seconds, push the "off" button and the lamp should light its full length. Repeat this if the lamp doesn't start; it may need more preheating.

In using the manual starter to test fixture equipment, a good lamp must be in the sockets. If it lights normally with the manual starter, the old starter button was at fault and must be replaced. However, if no glow is seen at the ends of the tube with the switch on, there is an open circuit that must be found.

To locate the open circuit, first twist the tube gently back and forth in its sockets with the manual starter button on. If the

Early and later fluorescent-lamp circuits, and some of the auxiliary units used with them. A still newer circuit requires only one control unit for four 100-watt lamps instead of two ballasts as used before

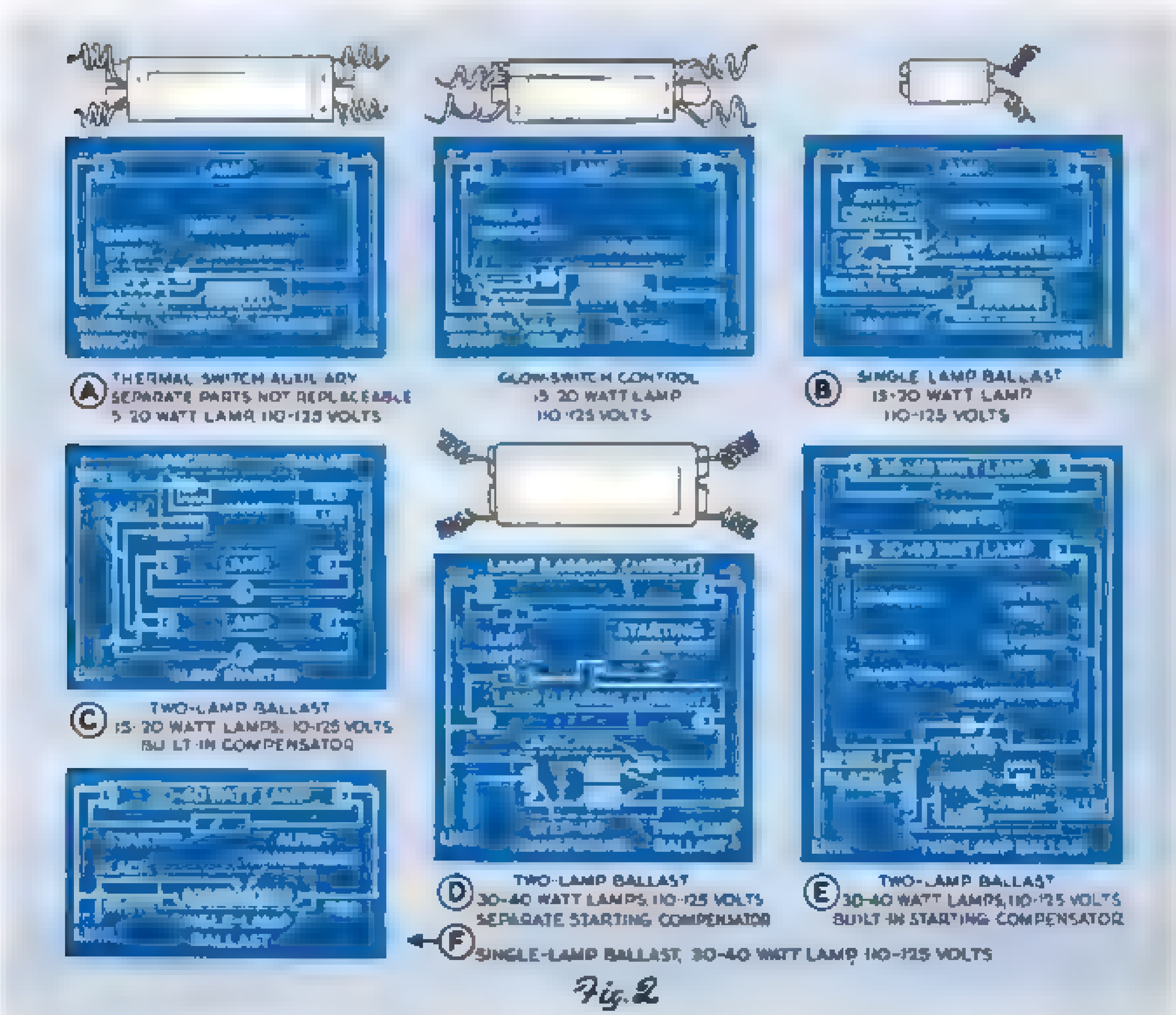
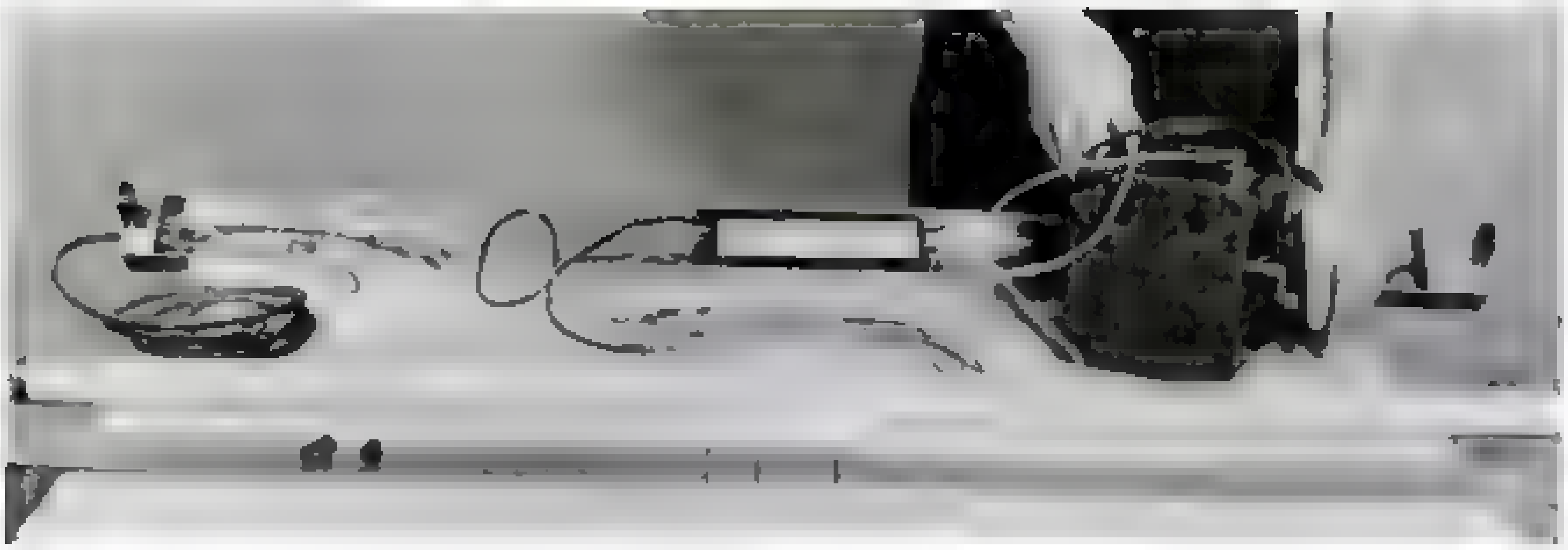


Fig. 2



If no glow appears at the ends of a good tube with the manual starter "on," there is an open circuit. Here the ballast windings of a 40-watt fixture are being tested with the help of a bell-ringing magneto

trouble is poor socket contact, the lamp will flash or start to glow when this is done. Replace any sockets in which the springs cannot be adjusted to make good contact.

If this test does not locate the open circuit, make sure the power is off by opening the service switch at the meter, disconnect the fixture, and remove it to the bench for further testing. One of the accompanying photographs shows a 40-watt fixture of the channel type opened for inspection. The exposed wiring is checked with *F* in Fig. 2.

Terminal points are inspected to make certain that they are tightly connected and that no stray strands of wire are touching the metal of the fixture. Splices also should be examined to make sure they are tight and properly taped.

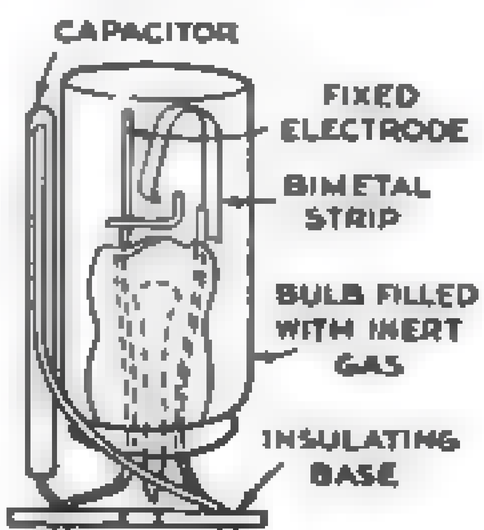
The ballast can be tested with a bell-ringing magneto, as in the photograph. An open circuit means it must be replaced. In fixtures using two-lamp ballasts, crisscrossed wires may cause faulty operation. Check the circuits against diagram *D* or *E* in Fig. 2.

It will be noted in the drawings that a simple reactor ballast is used with 15- and 20-watt lamps, but for the longer 30- and 40-watt lamps an auto-transformer type is required on 110-volt lines to step up the voltage for starting. Nowadays two-lamp ballasts are recommended instead of two single units for twin lamps, because of their greater efficiency and the elimination of any stroboscopic effect.

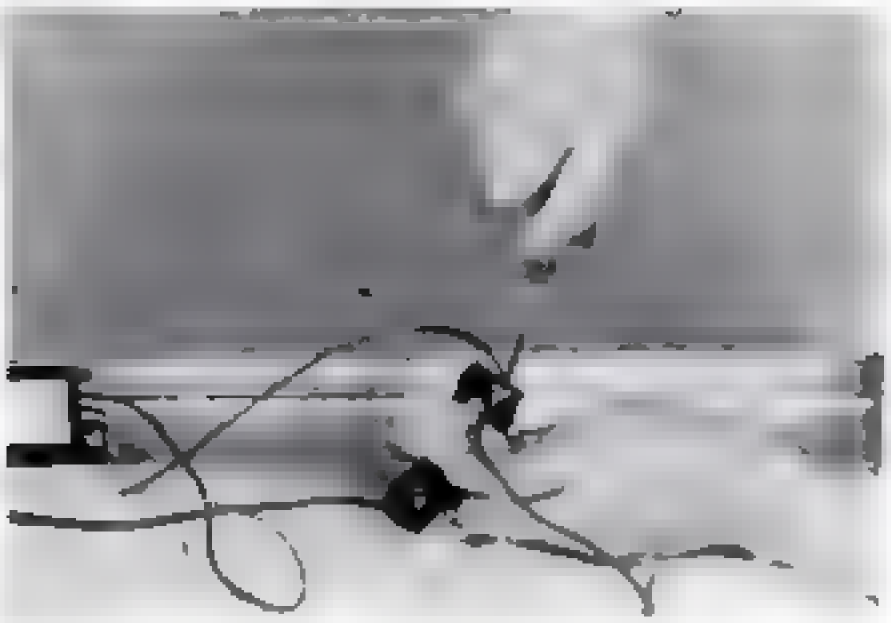
An early type combination thermal switch reactor and capacitor, which was sealed in a single unit, has been largely replaced with separate ballasts and replaceable starters, but such combination units will still be found in many of the older fixtures. Where any part of one is defective, the entire auxiliary must be replaced.

HOW A FLUORESCENT-LAMP STARTER WORKS

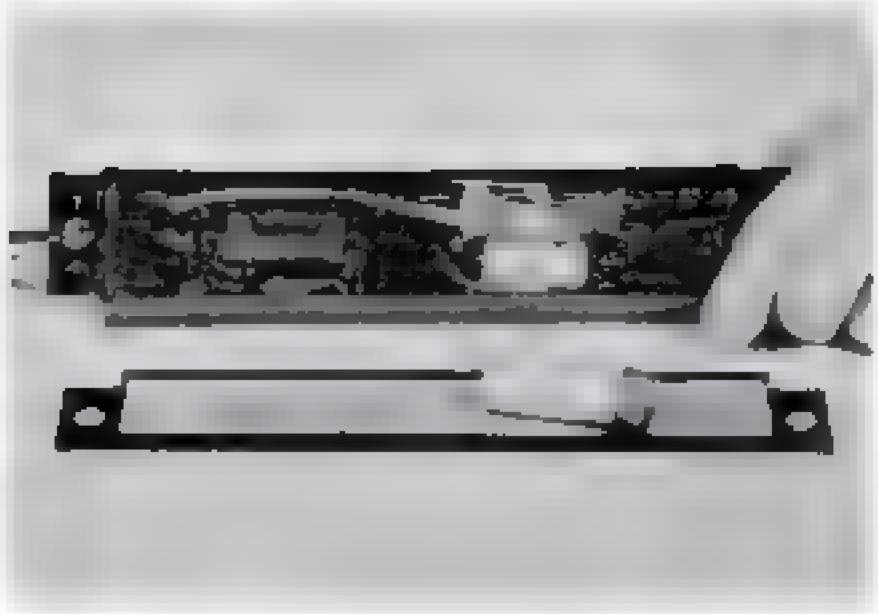
THE popular glow starter consists essentially of a fixed electrode or contact and another made of a bimetal strip. These are separated under normal conditions and form part of a series circuit through the lamp electrodes and the reactance or ballast. When the voltage is applied, a glow discharge takes place between the two open points, but very little current passes at this time. However, the glow causes a heating effect which after a second or two expands the bimetal strip until the contacts touch. This short-circuits the switch, and a substantial current now flows through the circuit to preheat the lamp electrodes. There is enough residual heat to keep the points closed for a short time; then, because the glow discharge is absent, the contacts again open as the bimetal cools and contracts.



At this instant, a high-voltage surge takes place in the circuit, due to the self-induction of the reactance, and strikes the arc in the tube. If the arc fails, the action is repeated. After the lamp has started, the starter points remain open because the voltage drop across the arc reduces the potential below that necessary to close them.



Even a loose connection may cause an open circuit. Check the wiring and tighten terminal screws well



The parts of the first auxiliary unit were sealed in a case and could not be replaced individually

Sometimes an objectionable hum is heard from a fluorescent fixture. This usually comes from the ballast, and insulating pieces of cork or rubber can be fitted under the unit to lessen the transmission of the noise. Tightening loose mounting screws may eliminate the hum. If in spite of these measures the noise remains, the ballast is probably defective and should be replaced.

A lamp that lights and then develops a flicker or flash may be near the end of its life and should be taken out of the circuit. Trying it in another fixture will prove this point. As a rule, such a lamp is badly blackened at the ends and, on being started, glows distinctly red at the ends before finally striking the arc. A defective starter can also cause this flashing, and the manual starter should be used as a check. Sudden drops in line voltage also will make the lamps blink sometimes.

A snaky, wavelike effect is sometimes apparent in the glow of the tube, particularly with new lamps. This is usually due to improper aging at the factory and will work out in use. Turning the lamps off and restarting them after a few minutes may eliminate it. Improper starting can also cause this effect, so if the tube is not a new one the starter should be checked.

If a lamp glows at the ends without flashing its full length, the starter contacts have stuck in a closed position. Replace the starter at once to avoid damage to other parts.

When in a fixture under test little or no glow is noted at the ends of the lamp with the manual starter switch on, but the tube makes a feeble attempt to light when the switch is snapped off, the filaments are probably receiving too little preheating current because of low line voltage or poor wiring connections.

PLATING WITH ALLOYS [ELECTRICAL]

Although alloys are usually formed by melting together dissimilar metals in a furnace, some of them can be formed by electroplating. Anodes of each metal are suspended in a proper electrolyte and deposition of the two metals proceeds in the same manner as with a single metal. Sometimes separate rheostats are employed to control the amount of current to each anode and thus the amount of each metal deposited. However, for small operations it is sufficient to use anodes of a proportionate size, or to immerse more or less of the anodes in the electrolyte. Utmost caution must be exercised in handling the solution, as all the cyanides used are deadly poisons.

Zinc-cadmium alloy combines the good properties of both metals. A suitable electrolyte consists of 10 oz. sodium cyanide, 1 oz. caustic soda, 3½ oz. cadmium oxide, 1 oz. zinc cyanide, and 1 gal. water. Dissolve the caustic soda and sodium cyanide in 2 qts. hot water. To the other two ingredients add enough water to form a thin paste and add it, while stirring, to the hot cyanide solution. Stir until it is all dissolved, then add the remaining water.

Brass. Cast anodes of 65 percent copper and 35 percent zinc are standard, but annealed sheet brass of the required color may be used. To control the color of the deposit, use strips of copper and zinc in the desired proportion. A standard electrolyte formula calls for 6 oz. copper carbonate, 3 oz. zinc carbonate, 1 lb. sodium cyanide, 2 oz. caustic soda, 1 oz. ammonium chloride, and 1 gal. water. Dissolve half of the cyanide in part of the water and add the copper carbonate. In the remainder of the water dissolve the rest of the cyanide, the caustic soda, ammonium chloride and zinc carbonate, in that order. Mix the solutions.

Imitation bronze. Use anodes in the proportion of 90 percent copper, 10 percent zinc. The electrolyte consists of 5 oz. sodium cyanide, 4 oz. copper cyanide, ½ oz. zinc cyanide, 2 oz. sodium carbonate, 2 oz. sodium potassium tartrate. Dissolve in 1 gal. water.

Silver-nickel alloy is sometimes used as a plating for the reflectors of automobile headlamps. Dissolve 12 oz. sodium cyanide, 2 oz. silver chloride and ¼ oz. nickel cyanide in 1 gal. water. Commence plating with a strike current of about 4 volts; then reduce it to 1 or 2 volts for the remainder of the plating time. Use silver anodes and replenish the nickel cyanide as becomes necessary.

POPULAR SCIENCE MONTHLY SHOP DATA

MODEL-RAILWAY SWITCHWORK Completing

By DAVID MARSHALL

YOU begin the building of a turnout in this wise: First, you lay the stock rail, *AB;* next the angle, *GFH;* then the lead rails, *M* and *N*. That brings you to the stage illustrated in Fig. 1.

As we have noted previously, the angle is formed of two rails, mitered or otherwise brought to a sharp point. That point becomes the *tongue of the frog*, and its angle determines the dimensions of the turnout. A 6-to-1 angle gives a No. 6 frog, a 7-to-1 angle a No. 7 frog, and so on. However, a No. 8 frog is the longest and sharpest you'll ever meet with on a model pike; a No. 6 is the shortest and bluntest allowed by the rules of the National Model Railroad Association.

As we have also noted, the lead rails vary in length according to the angle of the frog. Thus the diverging lead, *M*, will measure, in *O* gauge, with a No. 6 frog, 7⅝"; with a No. 7 frog, 11⅛"; with a No. 8 frog, 13 1/16". Beginning at the frog, *M* is laid absolutely straight for the first 3", and the only curve is that which results from your bending the free end slightly away from *AB* so as to leave a ¼" flangeway between the two. The main lead *N* is originally as long as *M*. When both are securely spiked in place, you cut off a slight bit of *N*, so that *M* and *N* terminate on a line perpendicular to *AB*. In each instance the figures just given include 1" of lead rail to be bent sharply to one side to form the wing rail.

All this was explained in detail in the two preceding installments. To complete the turnout: (1) a switch is to be constructed and hung like a pair of gates upon the butt ends of *M* and *N;* (2) the diverging stock rail is to be laid; and (3) the guard rails are to be fashioned and spiked in place. (See Fig. 2.)

THE SWITCH. As we have said before, the switch is the movable element of a turnout, composed simply of the two points (*X* and *Y* in Fig. 2) and the tie-rod by which they are loosely tied together and controlled. On the grown-up railroads, the points vary in length according to the angle of the frog, just as the lead rails do. But the variation is slight; model railroaders ignore it. Today it is standard practice to use a 6" point with any one of the three standard frogs found on model pikes.

To attach a point to its lead rail, there is one correct method, which is also the easiest method. This is by the use of fish plates bolted firmly to the lead rail. The *heel* of the point is "prepared" to fit rather loosely between the fish plates; the web—the vertical part between the rail flanges and the head—is filed a bit thinner, and beveled. The bolt hole is made a trifle over size. Thus, when the point is bolted in position, the requisite movement between the fish plates is made possible.

THE TOE OF THE POINT. At the end opposite the heel, we have, of course, the *toe of the point*. To bring this to its proper shape, we begin by making three cuts, illustrated in Fig. 3. The first of these cuts is a vertical bevel, applied to that side which comes in contact with a stock rail. This will pass through the vertical center line of the rail at the toe end, and will cross the outer edge of the flange 2" (more accurately, 1 29/32") from the toe, as at *A*, Fig. 3.

The second cut is also a vertical bevel. This, however, is from the opposite side of the rail, and applies only to the head and web, not the flange. Like the first, this bevel can be 2" long; it also passes through the vertical center line of the toe end. Above the flange, the web is thus brought to razor sharpness. There is no head left at the toe end; in effect, the web stands rail high (*B*, Fig. 3).

The third cut is a diagonal bevel below the center line of the web on the stock-rail side. This (*C*, Fig. 3) can be a little more than 2" long. Its purpose is to make room for the flange of the stock rail, which has not been tampered with in any way; no nicks are cut in it to receive the points, for this is not done on grown-up railroads and so must be barred from model-railroad practice. Over a distance of 3", along the stock rail, the inside spikes are omitted; and when the point is pressed against the stock rail, it rides over the stock rail's flange.

Two filing operations remain. The first, made plain in the side elevation, Fig. 5, is to result in a gradual lowering of the height of the rail in the last inch or so before the toe is reached, so that the sharp vertical blade

the Turnout

in which the point terminates is finally 1/64″ less than rail high. And the second filing operation is to round off the upper corner at the toe end of the point.

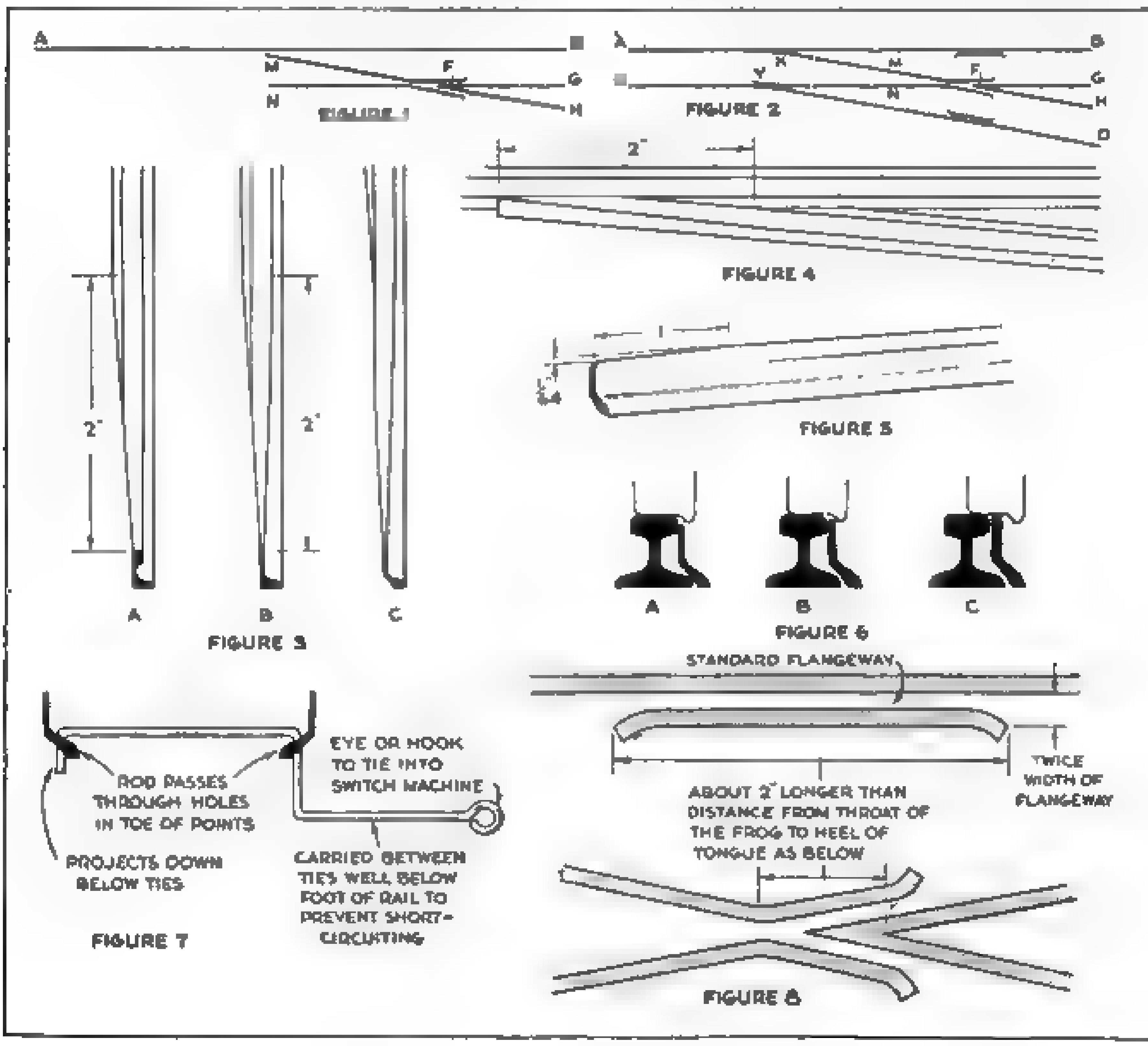
ENGAGING THE WHEELS. Thus made, the points are not only true to standard railroad practice, but are almost infallible in action. In Fig. 6, for example, we see the process by which the point insinuates itself between the stock rail and the flanges of wheels entering the switch from the toe end. At *A*, the wheel is at the very toe of the point, riding in its normal position on the stock rail. The switch point is so low and so thin that no part of the wheel can touch it.

At *B*, the wheel has moved slightly farther along its way, and at this point the blade is somewhat thicker, somewhat higher. Here the first contact occurs. The flange alone is engaged; the wheel is shifted to the right, and thus the only strain imposed upon the blade is lateral—a horizontal thrust to the left, resulting from the train's resistance to the change of direction. This strain, however, is transferred wholly to the stock rail, and in the end it amounts to nothing but a squeezing of the upper edge of the blade between the wheel flange and the head of the stock rail.

At *C*, the wheel has moved still farther, and now, where it is fairly thick and rail high, the point makes its first contact with the wheel's tread, and begins for the first time to bear a portion of the load, while still receiving support from part of the stock rail.

THE TIE-ROD. With *X*, Fig. 2, duly attached to *M*, and *Y* attached to *N*, it remains only to connect *X* and *Y* with a tie-rod—a metal rod

The points, diverging stock rail, and guard rails complete our turnout. How to make the critical parts is shown below. Switches constructed by the method outlined closely follow standard railroad practice



1/16" or so square (Fig. 7). At one end this is bent downward to enter a hole drilled in the flange of one point, about 1" from the toe. At the other end the rod is passed downward through a corresponding hole in the flange of the other point, and thence is continued outward, below the bottom of the stock rail to provide a means of operating the switch.

The rod must be long enough to keep the points permanently 1" apart at the tips. Thus the movement of the points between the stock rails is limited to ¼", or, as we say, the switch has a "throw" of ¼", which is standard for O gauge.

COMPLETING THE TURNOUT. With the switch duly hung and thrown to the *open* position—with *X* hard against *AB*—we lay the diverging stock rail. Beginning at the left, we lay it strictly to gauge with *AB* up to a point within 1" of where the toe of *Y* is to strike

Inexpensive Fire Truck

BUILT for use in a suburban air-raid sector where small houses predominate, this fire-equipment truck can easily be handled by one person. As the total cost for materials was only 17 dollars, many sector or zone wardens should find this the answer to their need for an inexpensive emergency truck. If the wood is cut to size at the lumber yard, only a few hand tools will be needed to assemble it.

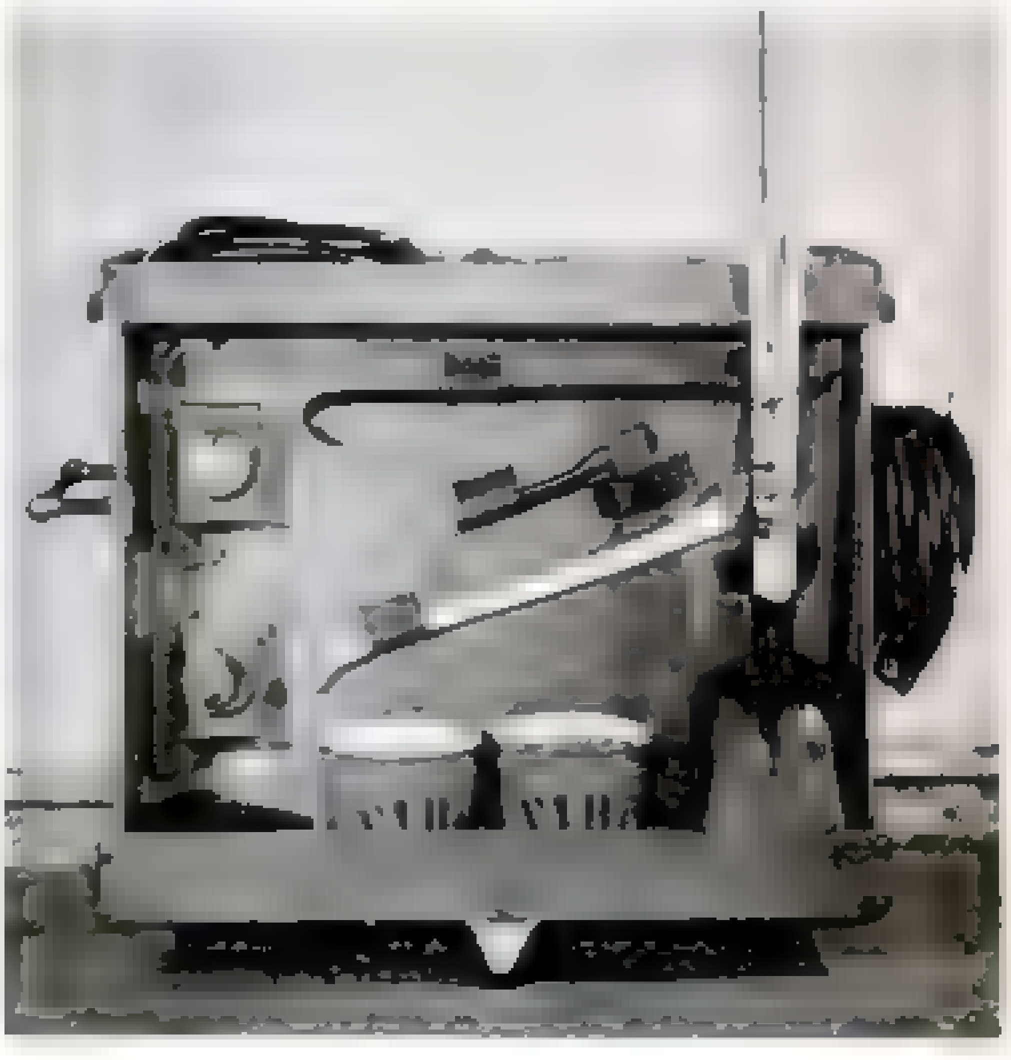
Start construction by nailing 1" thick boards together with three cross battens to form a floor. Around this, nail and screw fast the frame pieces. Reinforce the corners with trunk brackets or angle irons as indicated in the drawing

Attach nonswiveling truck rollers with stove bolts and nuts as shown in an accompanying photograph. The four 6" rubber-tired rollers used for the original truck cost six dollars. Insert a ¼" thick plywood shim under each middle one so that the truck pivots on these and only one end roller touches the floor at a time.

Nail in the tapering, ½" thick plywood ends and the center partition. Build the top with its floor set in ½" from the bottom edge. Use two pieces of plywood for each end of the top and small angle irons inside the corners. Attach this part with nails and angle irons. Finally, nail quarter-round molding all around the edges of the center partition on both sides where it meets the top, floor, and ends.

Nail a 4" wide vertical reinforcing strip to each end, and similar pieces crosswise both inside and outside where the handle is to be attached. The handle shown was built of pipe fittings. It is bolted fast 25½" up from the bottom edge.

The truck floor as seen from beneath. Rollers mounted as shown, with shims under the middle ones, enable the truck to turn corners easily



At right, the emergency truck loaded and ready for service. Total cost of all materials, exclusive of equipment and paint, was about seventeen dollars

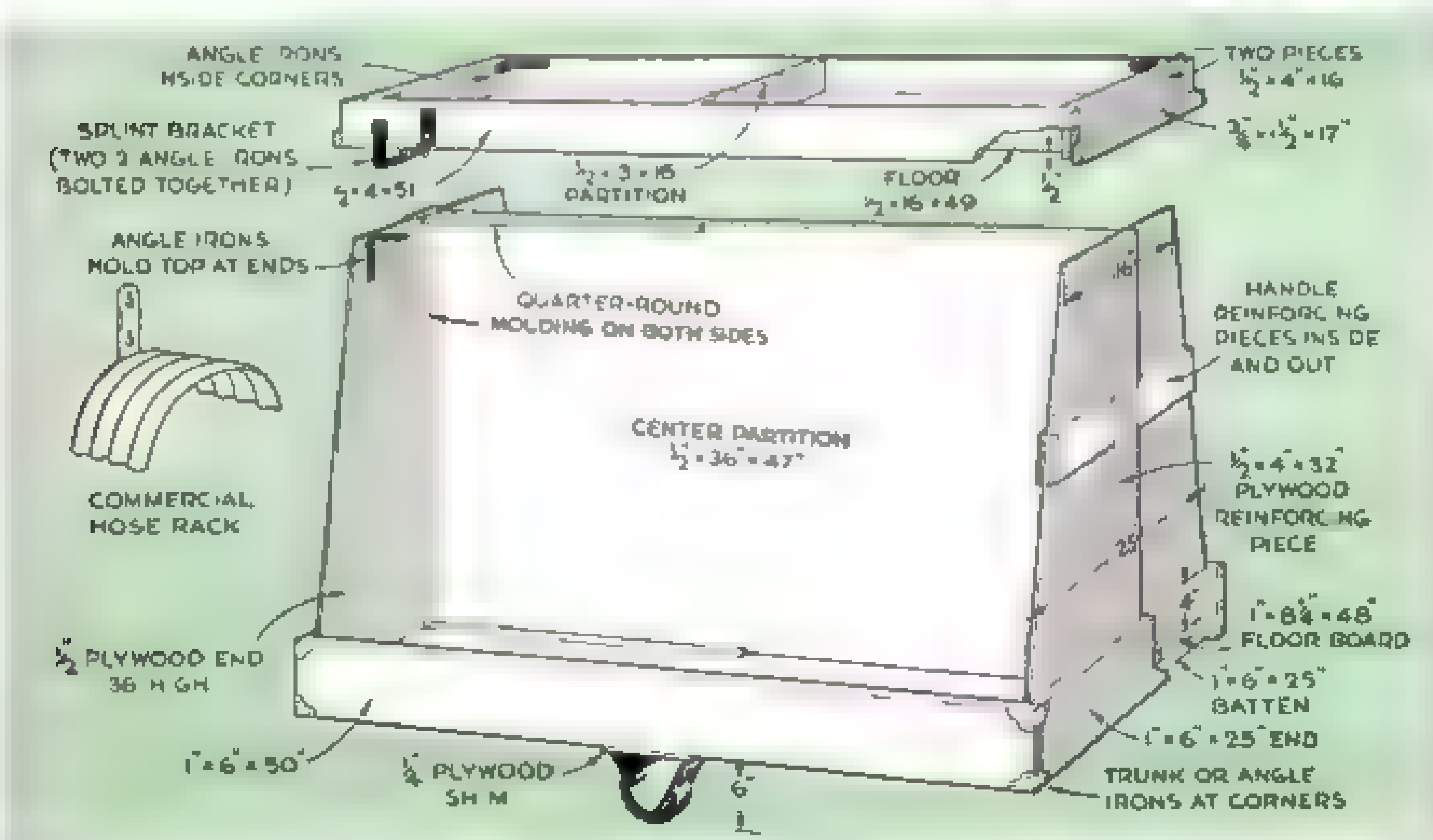
it. Within this inch, then, we slightly widen the gauge, though keeping it within the limits of tolerance for O gauge. Thus we develop a slight bend in *CD* opposite, and slightly in advance of, the *angle* formed where *X* meets *AB*. And after that, opposite *X*, opposite *M*, and opposite *FH*, the diverging stock rail is simply laid to gauge all along the line.

Last of all come the guard rails (Fig. 8). Their purpose is to shift all wheels hard against the stock rails opposite the frog, so that the flanges that pass through the throat of the frog are drawn close to the wing rails and cannot possibly enter the wrong channel or strike the tongue.

The guard rails should be approximately 2" longer than the distance from the throat of the frog to the heel of the tongue, as shown in Fig. 8. Bend the ends of each to provide twice the normal flangeway width where the wheel enters.

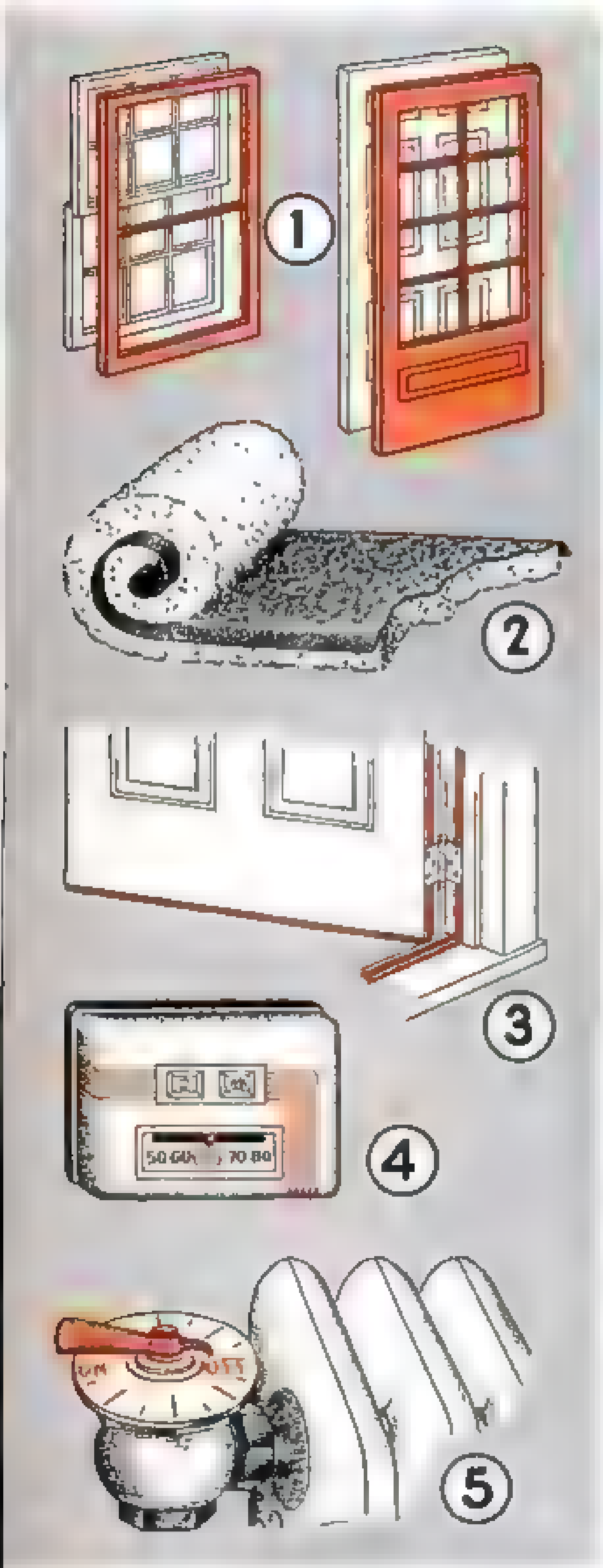
for Civilian Defense

Each splint bracket consists of two angle irons bolted together. Heavy-gauge scrap sheet metal was used for the brackets that hold equipment on the partition. These are attached in pairs, one in the same position on each side, so that one pair of bolts and nuts holds both. The hose rack was purchased for 59 cents. Lanterns are hung on screw hooks, and the shovels are held with sash chain. Extra hose, asbestos gloves, flashlights, clothesline, stakes, and helmets can be carried in the top tray.—BEN FELDMAN.



Ten Ways

A LIST OF SUGGESTIONS PREPARED BY THE AMERICAN



1 INSTALL STORM WINDOWS AND DOORS. Tests have proved that the application of storm windows and doors will save from 20 to 25 percent of the fuel ordinarily used. One advantage of tightly fitting storm sash is that it enables higher relative humidities to be maintained indoors without the accompaniment of excessive condensation on windows. Storm sash also reduces the down draft of cold air at windows. This, together with the increase of the so-called "glass-surface temperature," insures greater comfort. The addition of humidity permits a reduction in dry-bulb temperature without an quivalent reduction in comfort, but this in itself is not a factor in saving fuel. The savings outlined here and below are not cumulative, but if all precautions are taken, they may reach or even exceed 60 percent.

2 INSULATE YOUR HOME. The addition of adequate ceiling insulation is credited with saving from 10 to 15 percent. Wall insulation will save anything from 12 to 20 percent, depending upon conditions. The application of insulation has the effect of increasing inside wall-surface temperatures, thus improving comfort.

3 ADD WINDOW AND DOOR WEATHER-STRIPPING. This alone is a valuable aid in conserving fuel. Experiments conducted under scientifically controlled conditions show that the installation of weatherstripping will save from 5 to 10 percent. Savings are greater when the weatherstripping is applied to loose doors and windows.

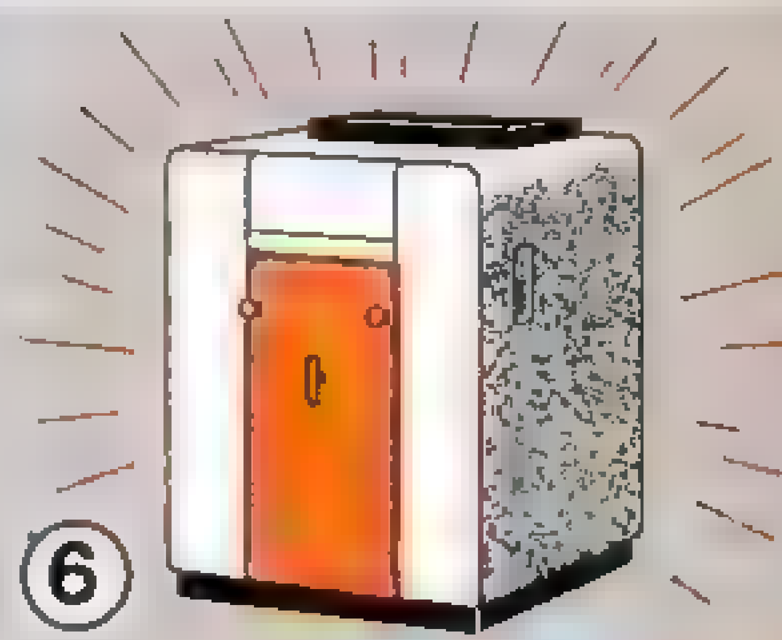
4 AVOID OVERHEATING. There are two suggestions for accomplishing this. One is to install thermostatic control for the maintenance of uniform temperatures between 65 and 70 deg. F. The other is a very obvious one—simply wear more clothing and avoid the necessity of higher temperatures.

5 DO NOT HEAT UNUSED ROOMS. Turn off the heat in the garage for the duration of the war. Since sun rooms are generally difficult to heat, shut them off from the balance of the house if possible. Keep doors tightly closed to attic spaces and any unused rooms. When bedroom windows are opened for sleeping, turn off the heat. The fireplace opening should be sealed and the damper should be tightly closed to prevent loss of heat up the chimney.

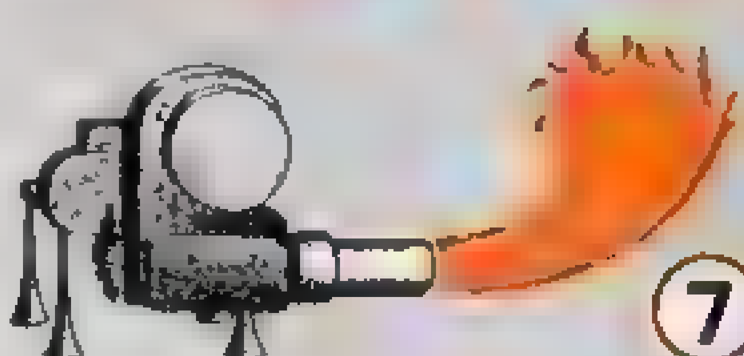
to Save Fuel

SOCIETY OF HEATING AND VENTILATING ENGINEERS

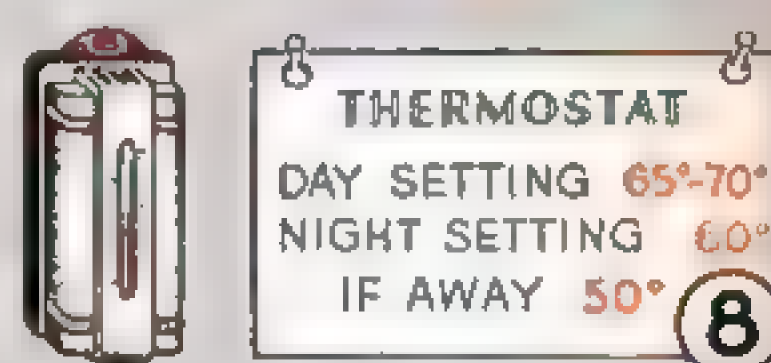
6 RECONDITION THE HEATING PLANT. Every heating plant should be surveyed and tested by a competent heating engineer or contractor. If the house is heated by a radiator system, the following points should be observed: 1. Inspect the insulation on the boiler. 2. Remove all pipe pockets and correct the pitch for good circulation. 3. Check the pipe insulation for defects. 4. Clean and repair air valves and radiator traps and valves. 5. Purge the air from radiators. If the system is of the warm-air furnace type: 1. Examine the air filter and clean or replace it. 2. Make sure all air-supply and return grilles are open and unobstructed. 3. Eliminate the introduction of any outside air into the cold-air side of the system and recirculate the indoor air 100 percent.



7 CHECK FURNACE COMBUSTION EFFICIENCY. The removal of soot from the inside surfaces of a furnace or boiler will save about 5 percent. Soot accumulation clogs the passages and reduces draft. Have the chimney draft, stack temperature, and percentage of carbon dioxide in the flue gas checked with the proper instruments.

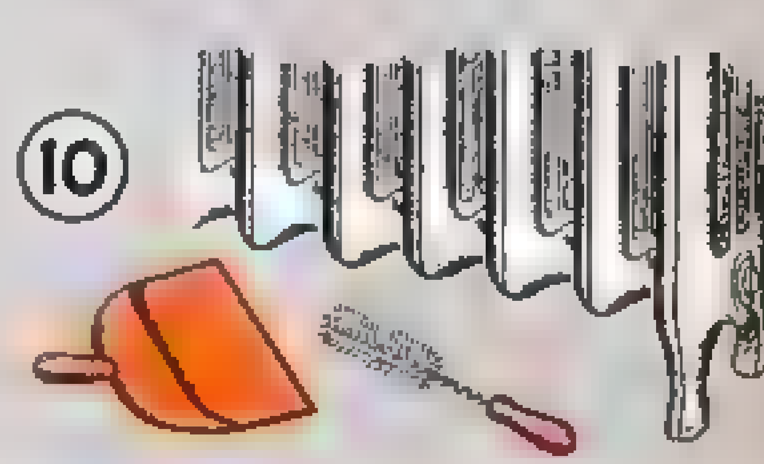


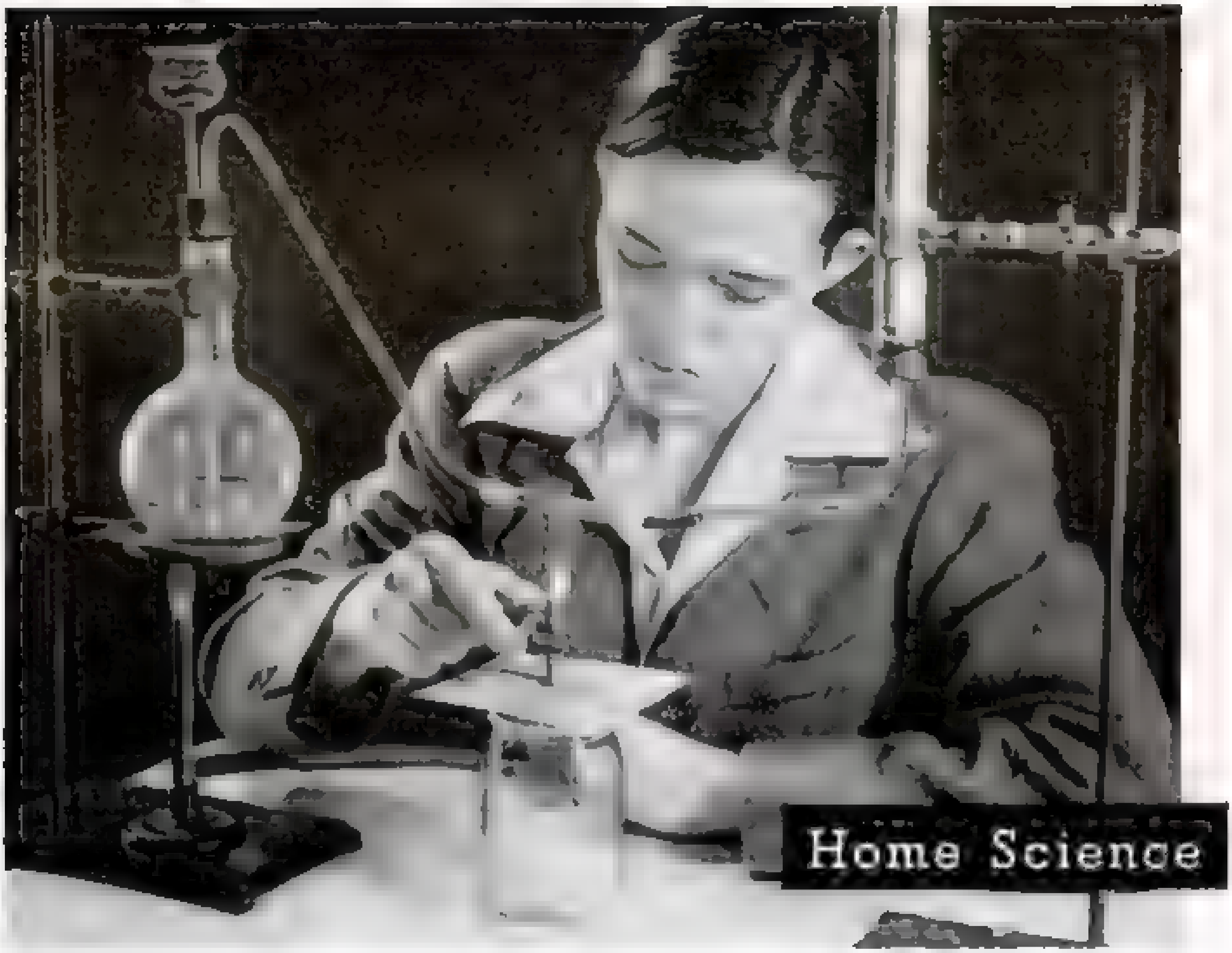
8 LOWER TEMPERATURES. Two ways to keep the temperature down are as follows: 1. Reduce the temperature at night to about 60 deg. F. This will result in fuel savings that range from 5 to 10 percent. 2. When away for a week-end or several days, set the thermostat at about 50 deg. F., which is sufficient to prevent damage from freezing.



9 INSULATE THE HOT-WATER HEATER. Modern hot-water heaters are usually well insulated, but there are innumerable old installations with exposed hot-water storage tanks. These should be insulated to conserve heat. Also be sure to fix every leaky hot-water faucet, because it wastes both water and fuel.

10 IMPROVE RADIATOR EFFICIENCY. 1 Remove any dirt that has collected in the pockets of radiators and convectors. 2. Keep heavy drapes and curtains away from radiators and the outlet grilles of convectors. 3. If the radiators have been painted with bronze or aluminum finishes, the application of ordinary oil paints will improve their efficiency as much as 10 percent. 4. Place a reflector (any surface having a high emissivity) behind each radiator. It will reflect into the room heat that is normally absorbed in the wall.





Chlorine is generated by heating manganese dioxide and hydrochloric acid in the flask at left. It is heavy, and flows into the center jar through a pinchcock, waste passing to the scrubbing tube at right

CHLORINE

Experiments Show How Industry Uses Versatile Gas to Effect Many of Its Common Miracles

LIFESAVER and killer—this is the Jekyll-Hyde role of chlorine, the greenish-yellow gas hitting an all-time production record. One extensive use is in the extraction of bromine from sea water for conversion into ethylene dibromide, which, with tetraethyl lead, makes antiknock gasoline. Others are in bleaching, in making dyes, solvents, fire-extinguishing liquids, insecticides, and chloroform, and in purifying water. In warfare—should it become necessary to use deadly gas—phosgene, mustard gas, and lewisite are compounds of chlorine. Titanium tetrachloride produces dense white smoke screens.

Chlorine may be produced by heating a mixture of hydrochloric acid and manganese dioxide. With apparatus set up as shown, you may obtain gas as you need it and prevent excess gas from escaping. Although chlorine is safe if handled properly, breathing much of it may cause nose and throat irritation. All the joints of the apparatus should be tight, and gas not actually used should be led out through a window or absorbed in a scrubbing column.

Put a little manganese dioxide in a flask that has a stopper fitted with a bent glass tube and a thistle tube the lower end of which extends nearly to the bottom of the flask. The scrubber tube should be about 1" in diameter and 12" to 18" long. It is filled loosely with lump lye or lumps of moist lime. A pinchcock in the setup allows chlorine to pass into either the scrubber or a container for your experiments. To generate chlorine, pour a little hydrochloric acid into the thistle tube and heat the flask gently. Place the outlet tube in a glass jar, passing it through a hole in a cardboard cover. A

Chlorine has such a strong affinity for hydrogen that (above) it extracts it with a burst of flame from warm turpentine soaked into a wad of cotton. At right, vapor from a bottle of ammonia blown across the tumbler, which now contains hydrogen chloride, forms white clouds of ammonium chloride

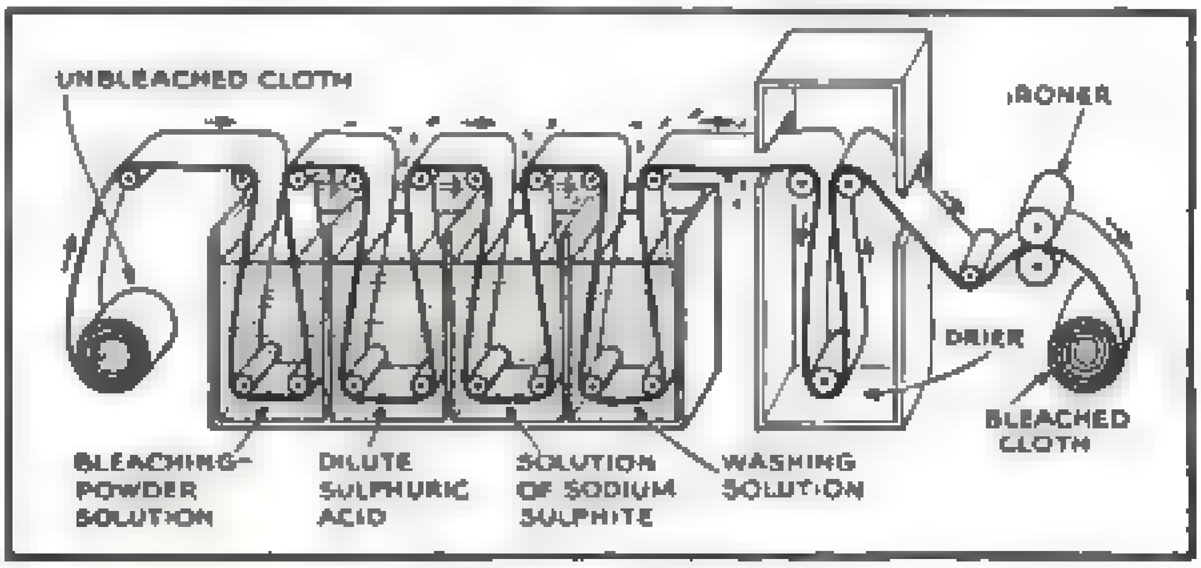
light behind the jar will show the heavy, greenish-yellow gas collecting.

Chlorine has a particular affinity for hydrogen. Soak a wad of cotton wool in warm turpentine, and put it in a jar of the gas. Hydrogen will be drawn violently from the turpentine, a hydrocarbon. Warm the turpentine by immersing a small beaker of it in boiling water *after* all fires have been extinguished.

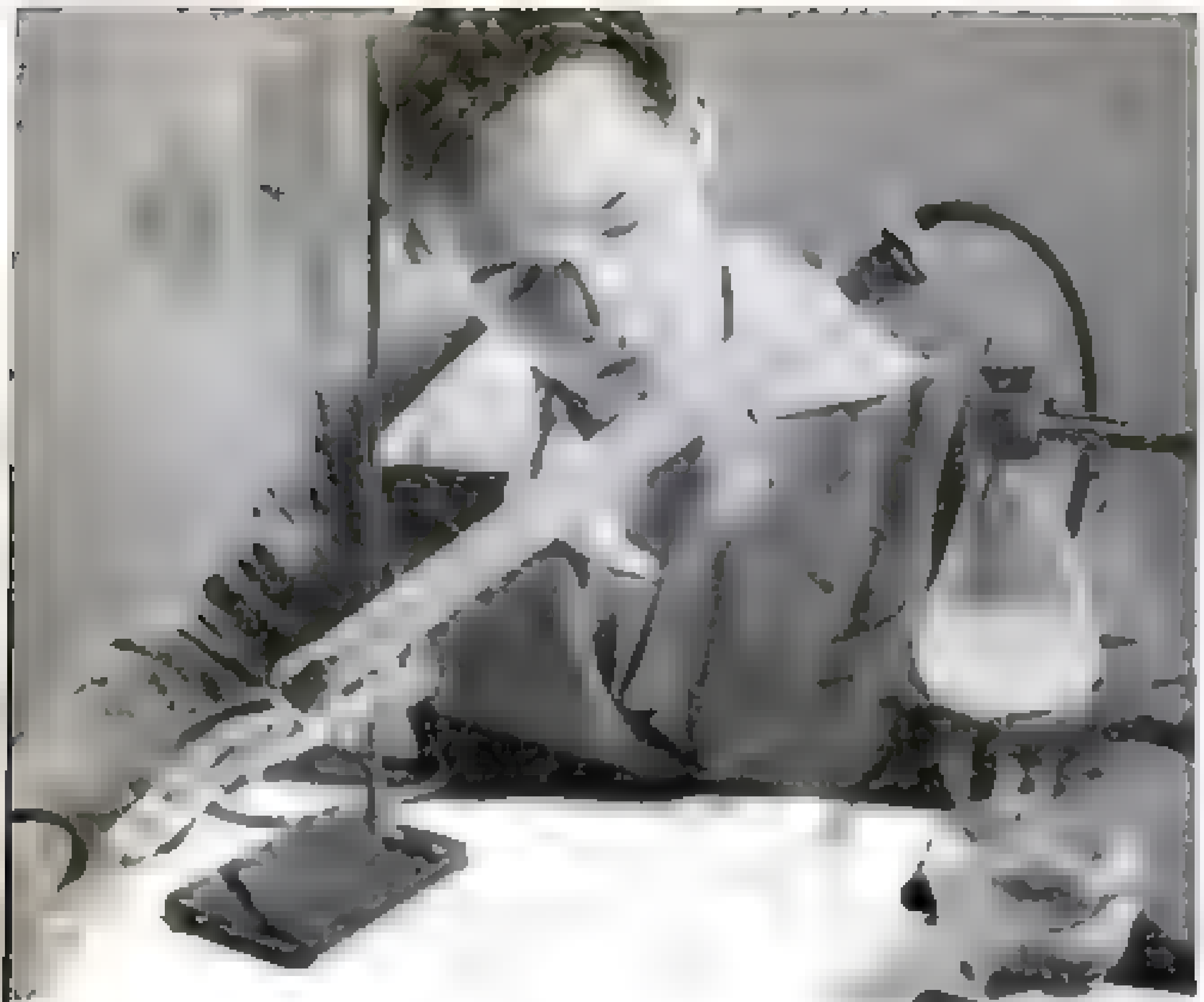
In the experiment chlorine combines with hydrogen to form hydrogen chloride. Now blow ammonia vapor over the glass in which the turpentine has burned, and a dense, white cloud of ammonium chloride will pour out.

Chlorine frees bromine from sea water by replacing it in its compounds. A few grains of potassium or sodium bromide, dissolved in tap water, will serve as sea water for our experiment. Shake up with the bromide solution a little chlorine water, made by bubbling chlorine through water or by adding a little acid to water containing bleaching powder. The clear bromide solution will turn yellowish or brown, indicating that the bromine has been freed from its compound. You can remove most of the bromine by adding carbon tetrachloride, and shaking. The bromine will dissolve, settling as a brown solution.

Chloroform may be made by heating chloride of lime, or bleaching powder, and a little acetone in water, and condensing part of the vapor. If you haven't a condenser, use a glass tube, 1" in diameter and 10" or 12" inches long, plugged at each end with cork bored with holes to permit a straight glass tube to pass through the center and short glass tubes at the sides. Water should enter the condenser at its



Unbleached cotton, immersed in the bleaching-powder solution at left, is bleached by action of sulphuric acid in the next glass, and cleaned of chemicals by sodium sulphite and plain water. The diagram shows how acid frees chlorine in the reaction



Chlorine is made by gently distilling a solution of chloride of lime (bleaching powder) and acetone. It collects in the test tube at left, and can be recognized by its sweet smell. Heat carefully so frothing won't carry liquid through the tube

Chlorine water added to a clear solution of potassium bromide (just below) will free bromine and turn the solution yellow or brown. Carbon tetrachloride dissolves the free bromine and causes it to settle as a dark liquid at the bottom of the tube

lower end, pass through, and flow out at the upper end.

In a 250 cc. flask put 20 grams of bleaching powder and 80 cc. of water. Add 4 grams of acetone, and connect the flask to the condenser by means of a bent tube and a one-hole stopper. Heat cautiously with a small flame until the mixture begins to froth, remove the flame until the reaction moderates, then heat until it boils, and continue boiling until no more oily drops pass over. Two layers of liquid will form in the receiving test tube, the lower one being chloroform.

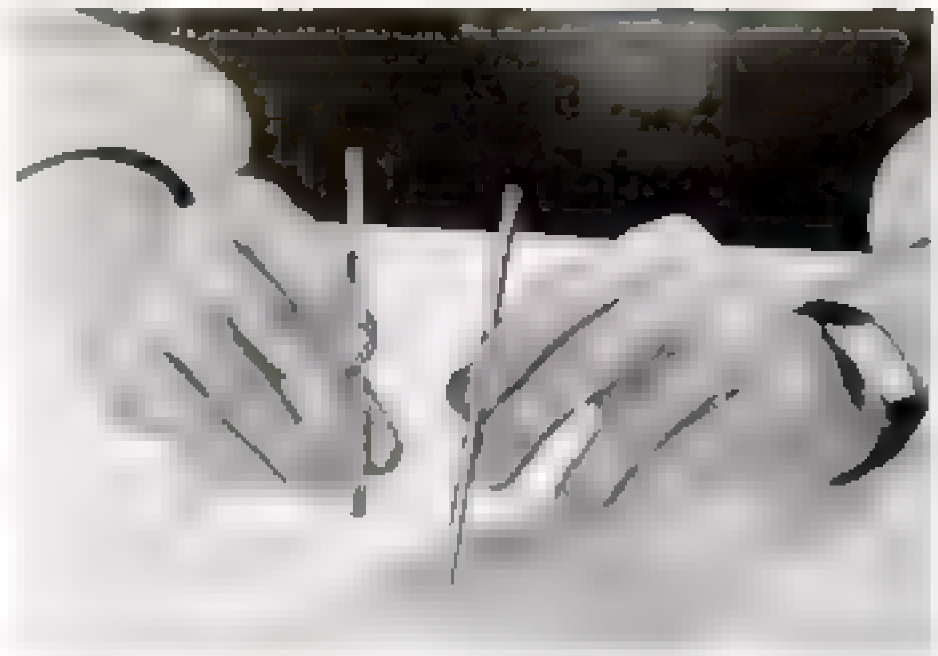
To bleach natural cotton—chlorine destroys silk and wool—wet unbleached muslin in a 10-percent solution of chloride of lime, and transfer it to a 5-percent solution of concentrated sulphuric acid, which will free the chlorine and form a solution of hypochlorous and hydrochloric acid. Hypochlorous acid bleaches by oxidizing natural coloring matter and some dyes. Immersion in a 5-percent solution of sodium sulphite will remove excess chlorine, washing in clear water the other chemicals.

To test bleaching power on dyes, suspend strips of moistened fabrics in jars of the gas. Water takes no active part, but is present as a catalyst. Dyed material that will bleach out completely in chlorine when moist, will not bleach at all when dry.

Chlorine gas will not bleach unless water is present as a catalyst. At right, two identical strips of dyed cotton—the one at left in the photograph dry, the other moist—are suspended in tumblers of the gas. The dry cloth retains its color, but the dampened one is quickly bleached white

home EXPERIMENTS

WATER IS AN INSULATOR. Contrary to common belief, pure water is not a conductor of electricity. Immerse two bare wires in a glass of distilled water and connect them in series with a pair of dry cells and your homemade galvanometer. Unless you touch the wires together, the needle will not indicate the slightest current. Put a little salt into the water and the current will start to flow. It is mineral salts and other impurities dissolved in ordinary water that give it the ability to carry electricity



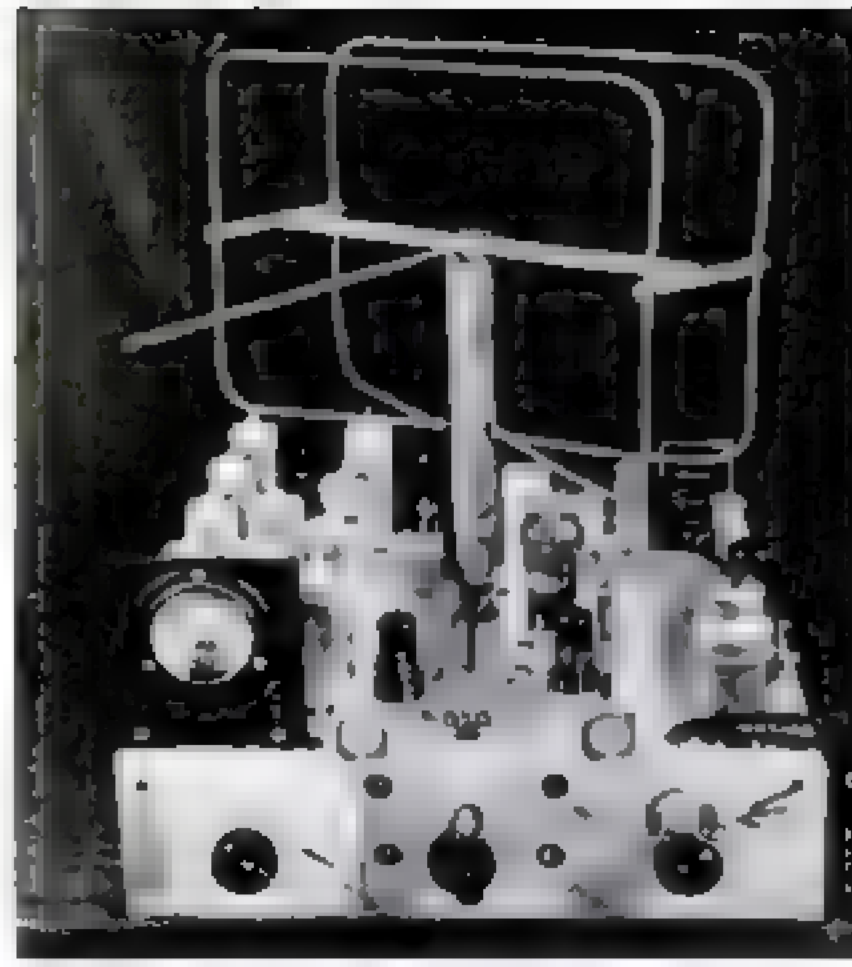
STUMP YOUR FRIENDS. Select a rod of steel and a similar one of soft iron. Magnetize the steel rod, and then ask your friends to tell which is magnetized, merely by rubbing them together. Here's the tip-off: Rub one rod along the length of the other. If the unmagnetized rod is used for the rubbing, it will be attracted strongly at the ends of the other, weakly in the middle. The magnetized rod is attracted all the way.

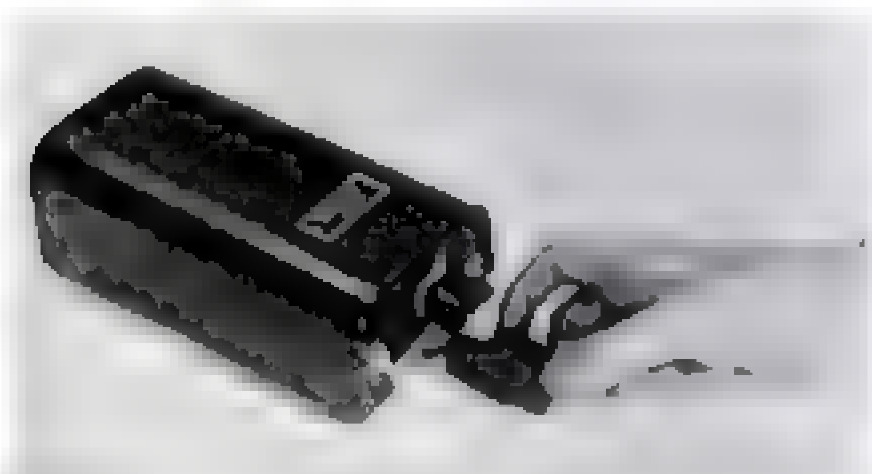
MODEL THERMOCOUPLE. Twist together the ends of a copper and an iron wire, and connect their other ends to your galvanometer. By applying different sources of heat to the twisted wires, you can cause the needle to be deflected by different amounts as thermoelectric currents are generated at the meeting place of the metals. This is the principle of some pyrometers.

SQUEEZE THE BOTTLE. You can compress a glass bottle simply by squeezing it with your hands. To prove it, fill a bottle completely with water and insert a stopper with a short length of drawn-out glass tubing protruding from it. Push in the stopper until the water rises in the tube. Now squeeze the bottle. The water will rise and fall amazingly as the pressure is applied and relieved.

Radio Ideas

BUILT-IN LOOP ANTENNAS for television receivers are being developed experimentally by the RCA Manufacturing Company, which finds that they may be used near a transmitter—within three to five miles for a city dweller. In office buildings and apartment houses of steel construction, dependable service is obtained in locations facing the transmitter. The two parallel turns of the vertical loop antenna pictured at right are connected to an inductor through a wave-change switch which provides for operation also on an outdoor antenna.



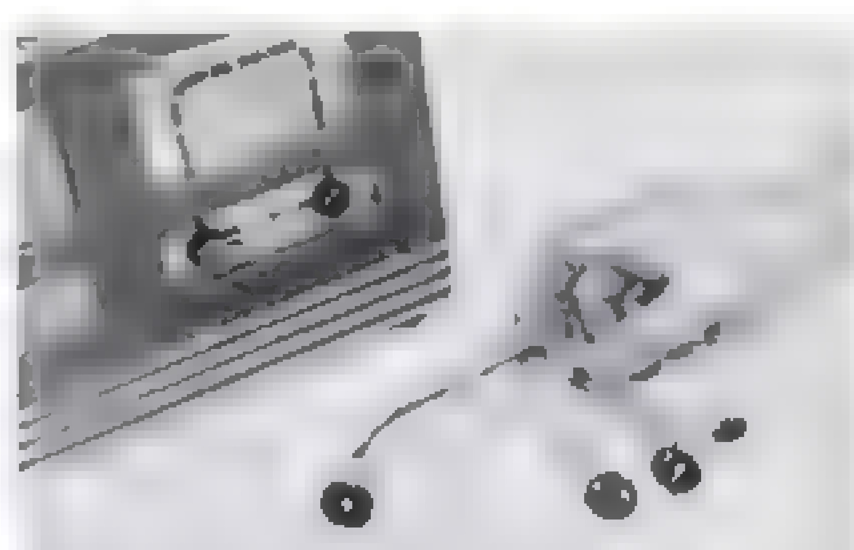


THIS ELECTRONIC "BUG" KEY has knob-control adjustment for sending from eight to 80 words a minute, with correct timing of dots, spaces, and dashes preserved automatically. Pressing a paddle to one side sends dots, and to the other, dashes.

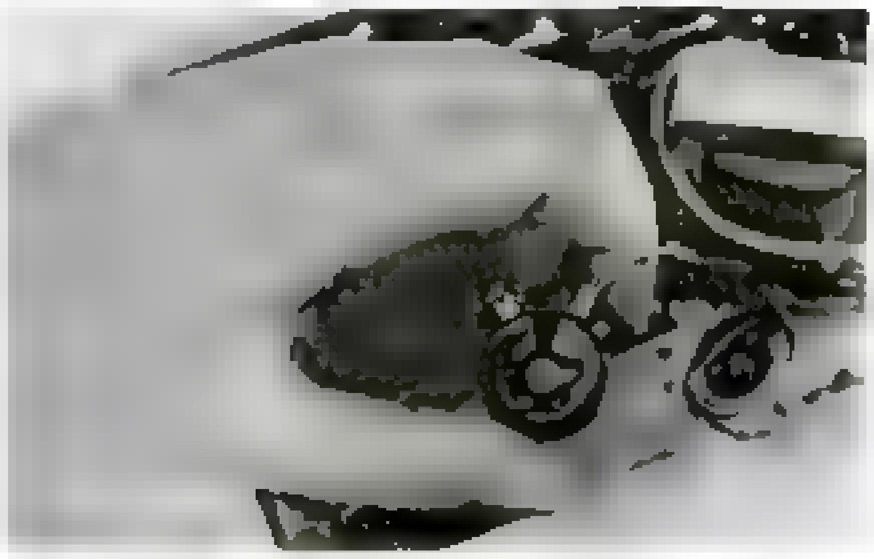
PLASTIC BOXES, made in several sizes and containing a variety of compartments, are on the market for use as repair kits and containers for small assembly parts. They were designed originally for carrying flies, lures, and other small fishing equipment.

TWO 4½-VOLT "A" BATTERIES may be used in place of a 7½-volt "A" battery if connected in series with the 25-ohm flexible wire-wound resistor shown below. The resistor reduces the total voltage of the batteries to that required by the receiver.

A NEW CONVERSION HARNESS makes possible the use of standard individual "A" and "B" batteries with a portable radio instead of special battery packs. It also enables replacement of any one exhausted battery without purchasing an entire new pack.



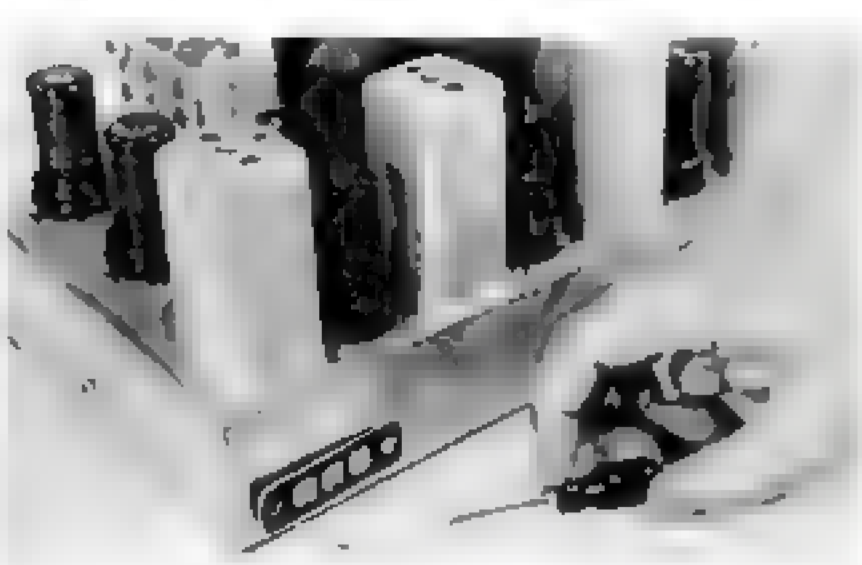
Servicing Your Radio— PART 8



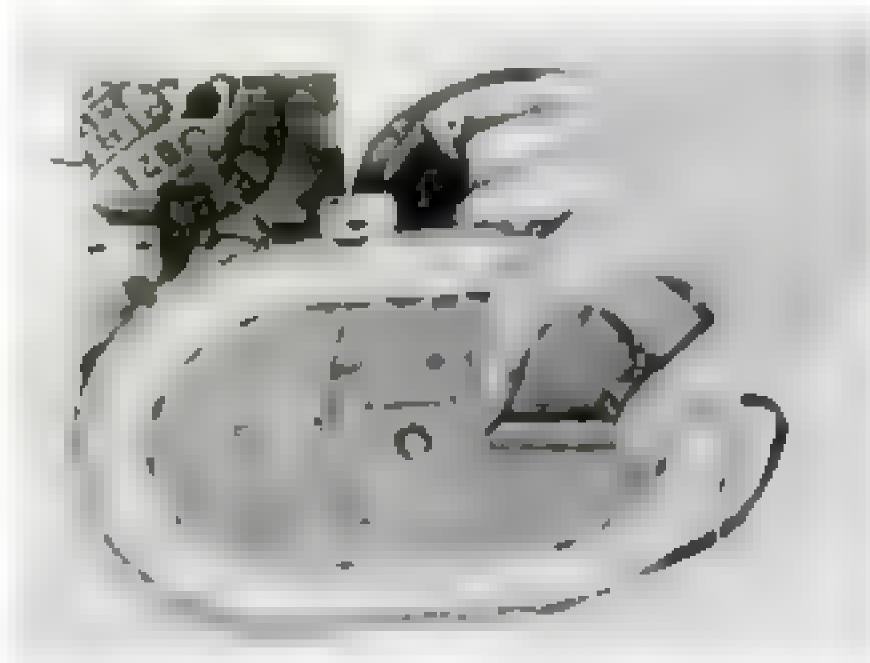
NOISY VOLUME CONTROL caused by the graphite wearing down or becoming coated with a hard film during the constant traction of the moving arm may be easily adjusted. Worn graphite can be restored with a dab of special liquid graphite lubricator. Film may be scraped away with a small screwdriver. Do not use a knife—it is too sharp—and do not scrape too hard.

SHOULD A SPEAKER GIVE NO SOUND even when the tubes light and test O. K. on the meter, the primary and secondary windings on the output transformer also test O. K., and each circuit is receiving the correct "B" voltage, it is a safe bet that the voice-coil winding is burned out. However, before cutting out the cone, make sure that the short pieces of stranded wire connecting the voice coil to the lugs on the speaker frame have not become corroded or disconnected. These are simple things which have happened in more than one receiver, and it saves needless trouble to inspect them.

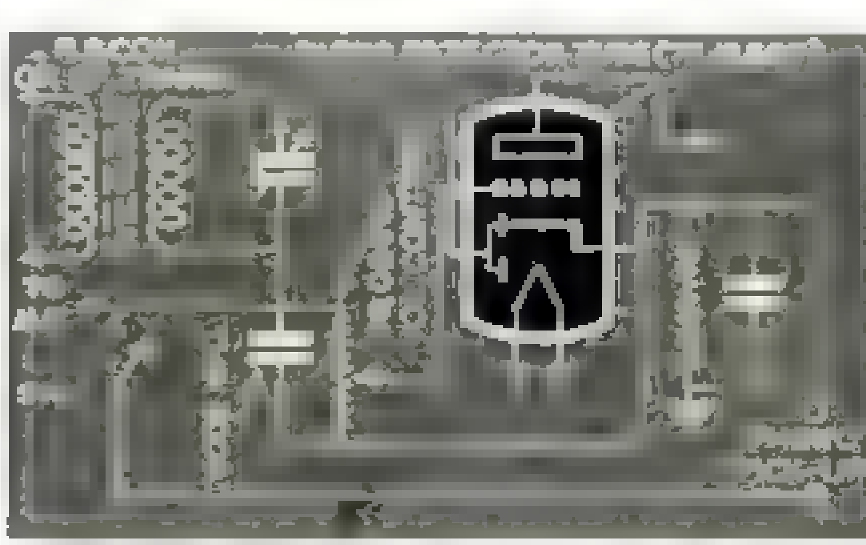
CONNECTING A PHONOGRAPH PICKUP to the detector stage of a radio receiver—an easy matter with the old receivers where the detector stage usually was a pentode—is a much more difficult operation with the newer models where the detector tube usually is a diode plus a high-mu triode or pentode.

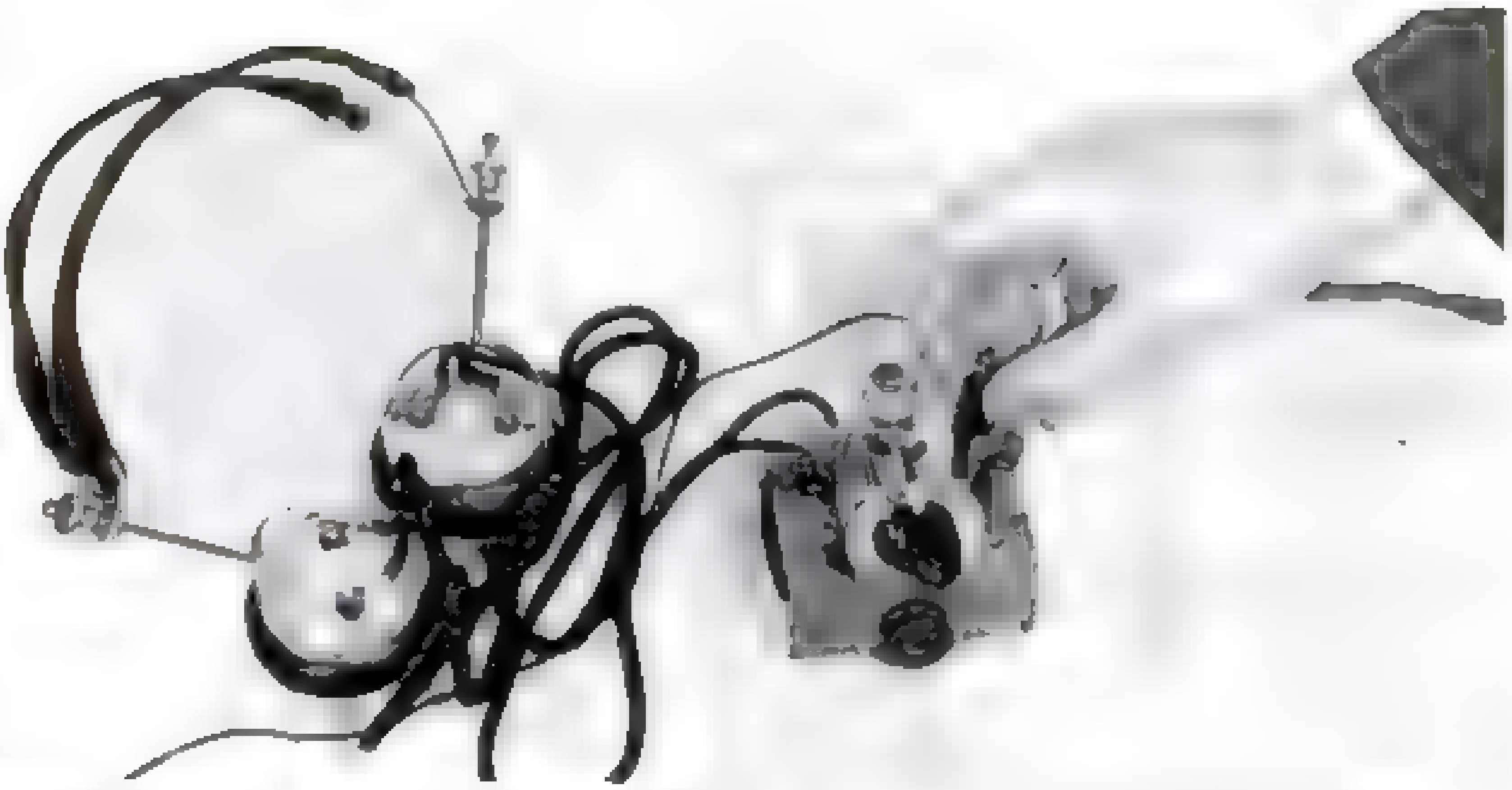


WHEN TUNING-STAGE ALIGNMENT, especially at the upper end of the dial, is not possible with a receiver using a loop antenna, reception may be improved in some cases by connecting a fixed condenser (.002 to .02 mfd.) across the loop antenna and ground, or by shorting the two.



By following carefully the diagram of the simple circuit given below, the amateur serviceman should be able to make the proper connection without too much trouble. This diagram will serve for any of the newer sets, and a connection thus made should give excellent phonograph reception.



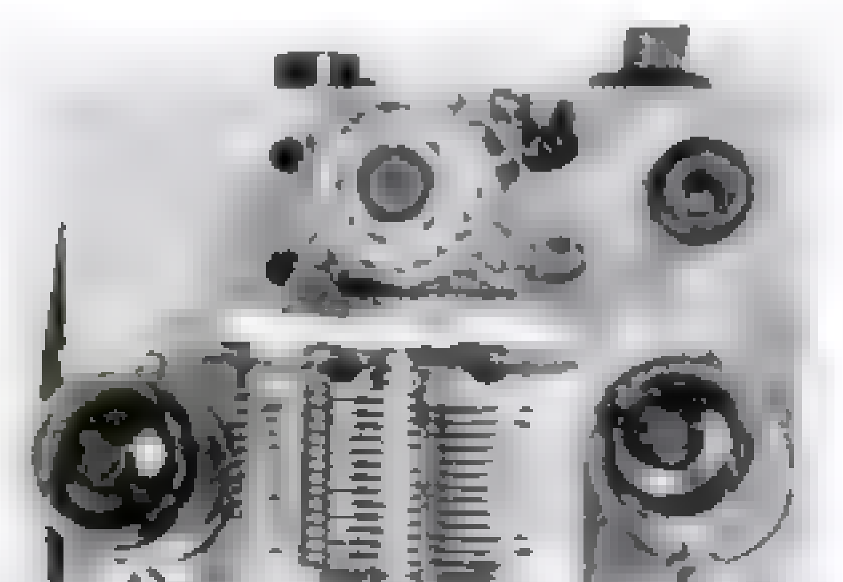


Beside the headphones, the tiny receiver is dwarfed. The plug being inserted is for the antenna

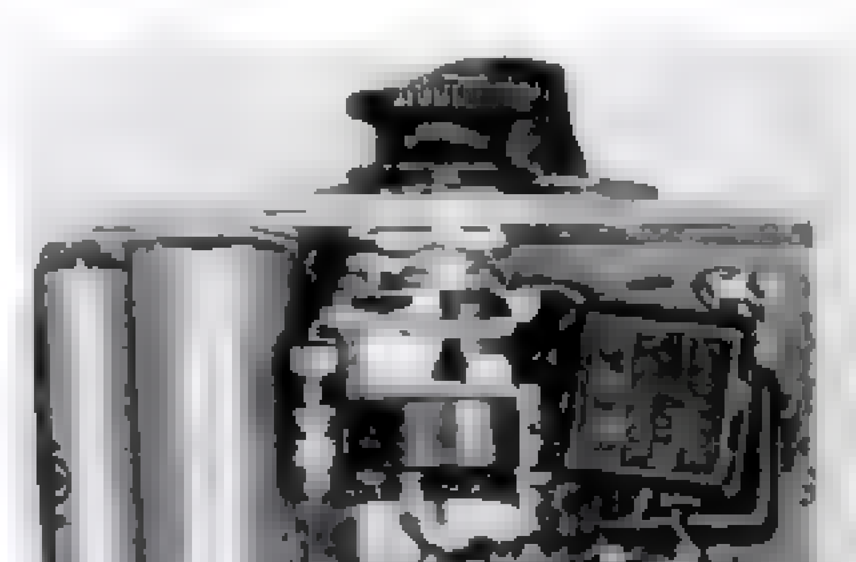
Two-Tube AC-DC Receiver

BUILT on a tiny chassis measuring only 1¼" by 2¼" by 3", this two-tube AC-DC headphone receiver is still powerful enough to pull in many stations besides the local broadcasters. No ground is used with it, and for an antenna a short piece of wire—about 18' long and strung along the floor—will be found sufficient for adequate reception in most cases. The little radio is selective enough to separate local stations and bring them in with great clearness.

Two of the newer midget tubes—the 9001 and the 9002—are used, the 9001 as a pentode detector and the 9002 as a half-wave rectifier. The 9002 is really a triode amplifier tube, but it will also function satisfactorily as a rectifier when its plate and grid are joined together. The 9001 is an RF pentode tube with a high amplification factor. Used in the detector stage, it will enable the listener to bring in stations situated more than 600 miles away if the



View of the chassis from above. The RF pentode tube is on the right, the rectifier tube at left

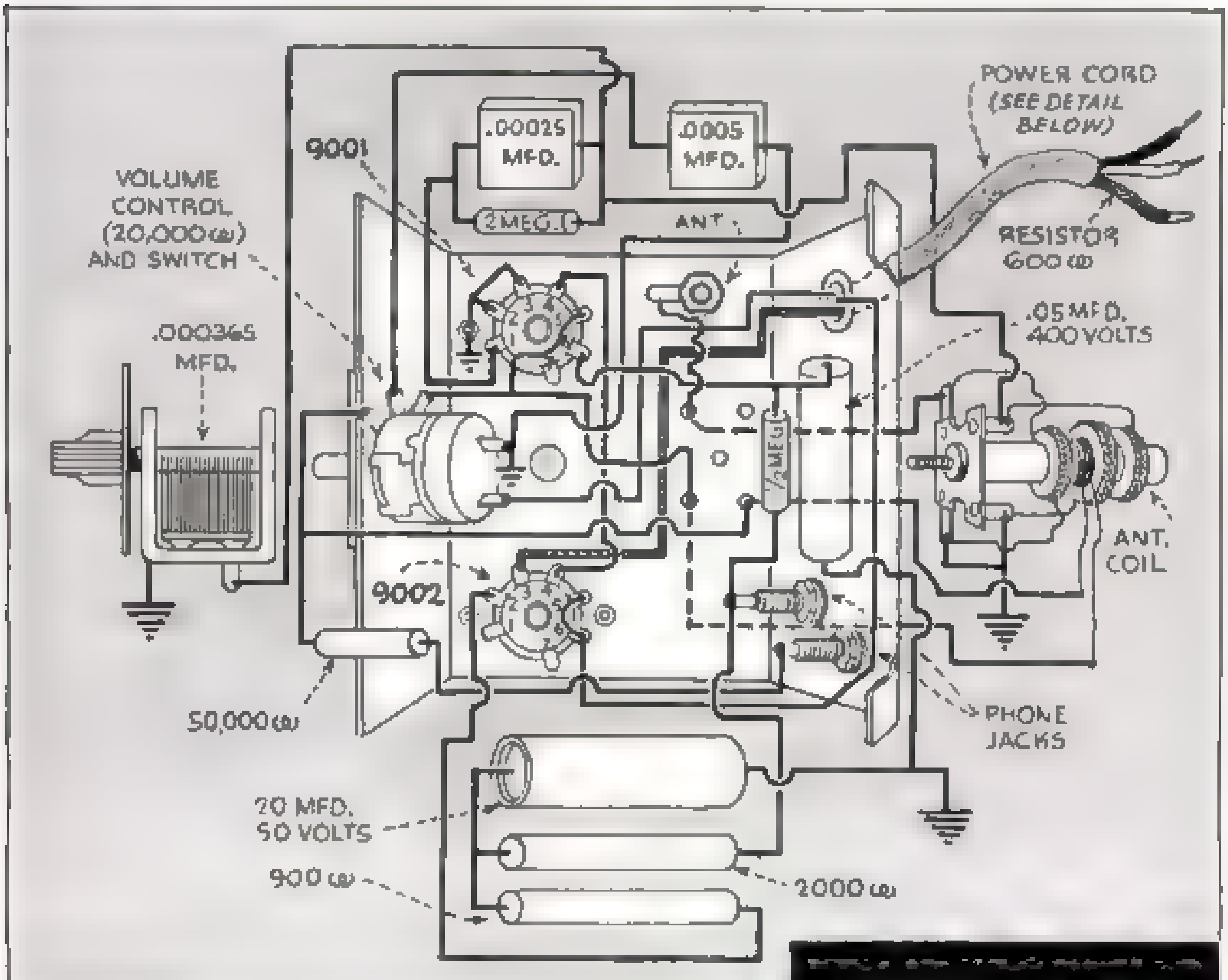


This bottom view shows one resistor at the left. The electrolytic filter condenser is next to it

receiver is used in the country and it is possible to put up a good outside antenna about 75' long.

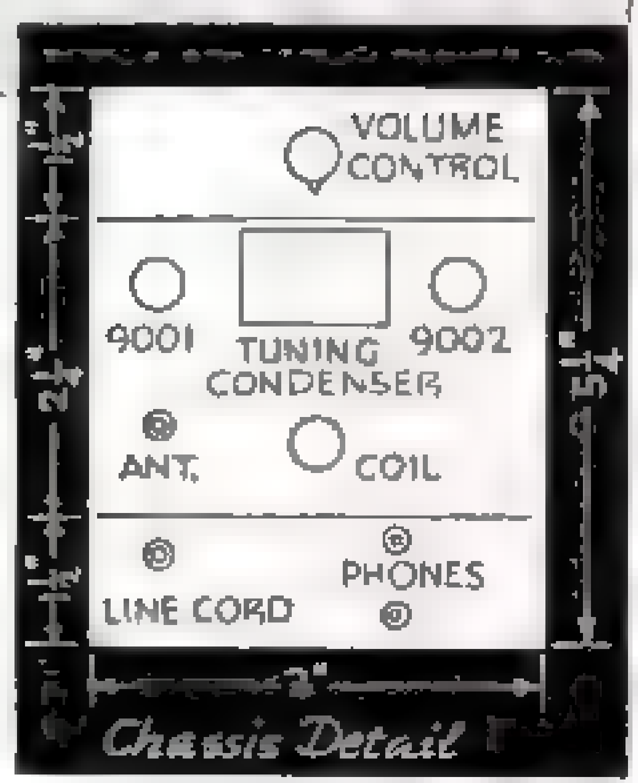
Because of the low heater-current drain (0.15 ampere for each tube), a line-cord resistor of 600 ohms is required. Since it is impossible to purchase a line cord higher than 350 ohms, two 300-ohm line cords are used in series to bring the resistance up to the amount necessary. The plug is removed from one line cord and the three exposed wires are then soldered to the ends of the corresponding wires of the second. To do this properly, be sure you disconnect the resistor from the wire to which it is soldered before attempting to join the two line cords. The method is illustrated in detail in the drawing at the lower left-hand corner of this page.

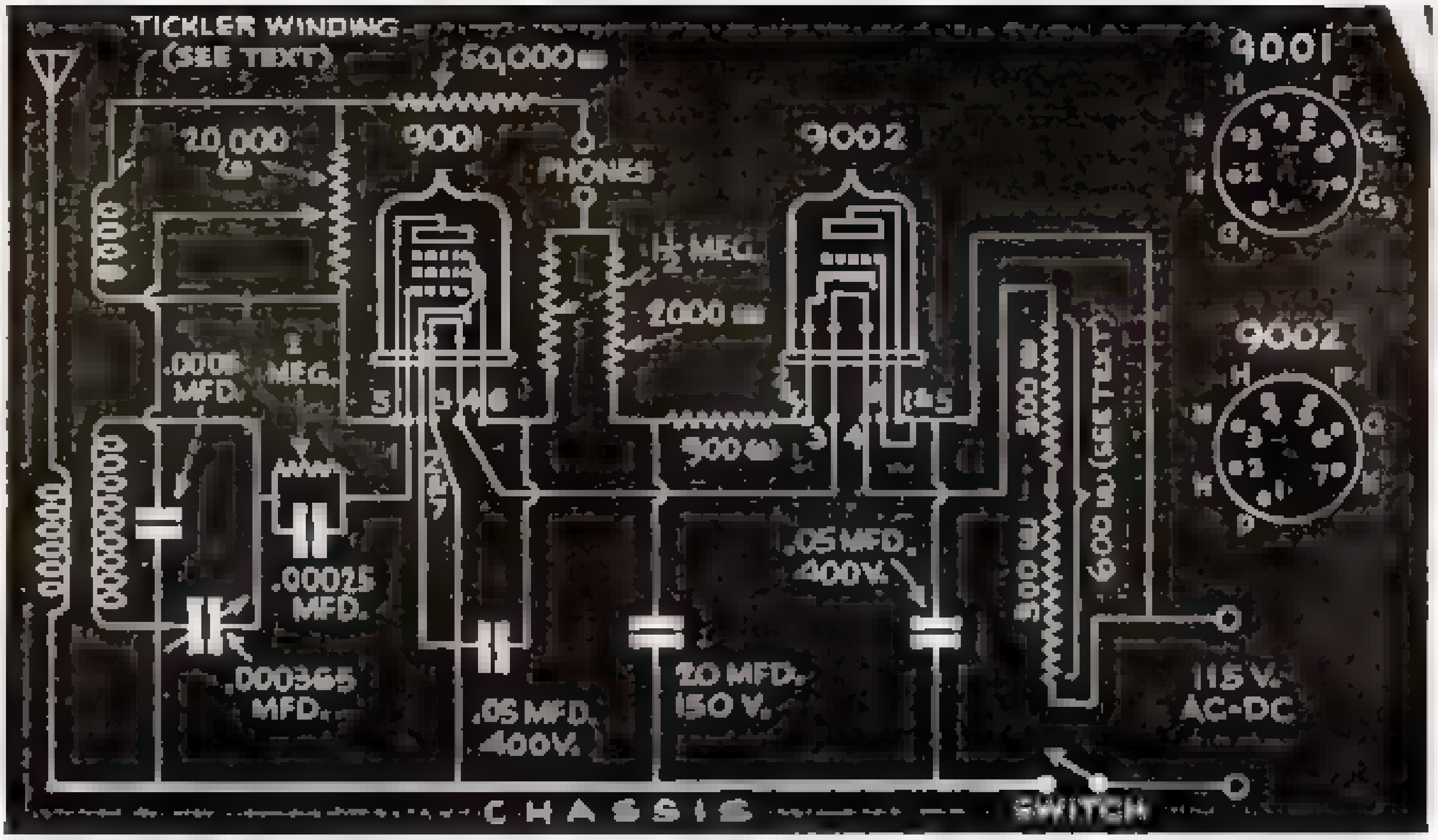
The capacities given in the wiring diagram are not critical, and both capacities and resistances (except that of the line cord) may vary as much as 25 percent. For instance, a .00041-mfd. variable condenser



Arrangement of the parts is detailed in the pictorial diagram above. Note that the tickler-coil winding is placed between the antenna-coil and the first of two secondary-coil windings

Two line cords, joined as shown in the sketch below, will be needed to obtain the necessary line-cord resistance. Follow the directions carefully. At the right is the chassis layout





Wiring is made simpler by following this complete diagram. Base layouts for tubes are at right above

LIST OF PARTS

- Midget tuning condenser, .000365 mfd.
- Midget iron-core antenna coil.
- Volume control, 20,000 ohms.
- S. P. S. T. switch.
- Midget pentode tube, 9001.
- Midget triode tube, 9002.
- Seven-prong sockets (2).
- Carbon resistors (5), 2 megohms, ⅓ watt; 1½ megohms, ⅓ watt; 50,000 ohms, ¼ watt; 2,000 ohms, 2 watts; 900 ohms, 2 watts.
- Line-cord resistors (2), 300 ohms.
- Electrolytic condenser, 20 mfd., 150 volts.
- Paper tubular condensers (2), .05 mfd., 400 volts.
- Mica condensers (2), .0005 mfd.; .00025 mfd.

Here the RF pentode detector tube is being inserted. It is all glass with no base. The midget socket is shown clearly

may be used instead of the .000365-mfd. condenser called for in the diagram, and the 2-megohm grid leak may be changed to either a 1-megohm or 5-megohm resistor. This 25-percent margin will enable one to rummage around in old sets or in the junk box for many of the parts.

The simplified filter circuit (using but one electrolytic condenser) is ample to keep any hum from reaching the phones. A tickler winding, consisting of 25 turns of No. 30 double-silk-covered wire, is wound next to the grid winding on the coil. The coil is a standard antenna coil of the type sold generally for use in small AC-DC receivers. Volume and oscillation are controlled by the 20,000-ohm variable resistor across the tickler winding.

The chassis is made of wood or any odd pieces of metal found around the workshop. A coating of gray wrinkle paint is applied to give it a professional finish. If a case is to be built, simulated leather or scrap may be used.—ARTHUR C. MILLER.

OUTDOORS

You're as good in winter as in summer — with Kodak Verichrome Film. Has remarkable "range." Gets the picture without bright sun. Make some snaps now for truly personal Christmas Photo Greeting Cards. See your Kodak dealer.

KEEP UP THE "SNAPSHOT VISITS"

Fall and winter snaps are so easy to make

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Super-fast Kodak Super-XX Film makes you as good indoors as out. You use a couple of inexpensive Photoflood bulbs and cardboard reflectors. Results are fine for greeting cards . . . Eastman Kodak Co., Rochester, N.Y.

Free Booklet on Snapshots at Night makes it easy to take the pictures that mean most to your boy in the Service . . . his family at home. Covers Photoflood and Photoflash. At your Kodak dealer's.

Outdoors . . . Indoors . . . you can always count on KODAK FILM

Gus Never Forgets a Car

(Continued from page 143)

two thugs had him in the cellar of a house up in the country, and for the last month they've been doing things to him trying to make him tell them how that gadget Johnson and Frederick is making for the Navy works. He kept on stalling them off by swearing that he didn't know, that he'd never seen the complete blueprints. Yesterday they threatened to put his eyes out if he didn't come across. He stalled them off again by giving them the combination of the safe in which the blueprints are kept. He figured that the plant is so closely guarded that they'd probably get caught or killed if they tried to get into it; they almost did, too—one of the guards took three shots at them. They used Holcomb's coupe, with stolen tags on it, for the trip—they had a big car of their own but they were keeping it under cover so they could use it to make their getaway. The G-men have the guys now. There's a spy-plot angle, of course. Say, Gus, how did you know it was Holcomb's car they brought in here?"

"I never forget a car I've worked on," Gus told him.

Jim scribbled on his pad. "One thing more," he said. "How did you know the coupe was going to stall where Jerry found it?"

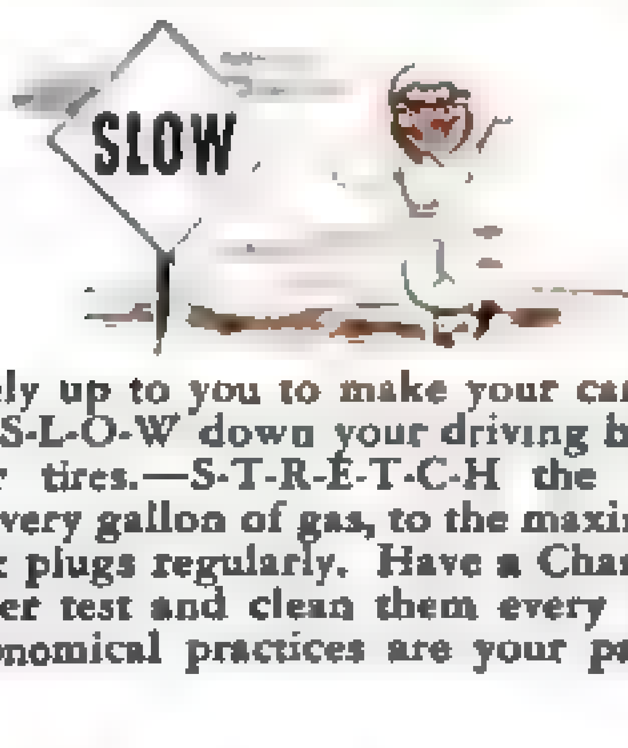
"That was mostly memory, too," Gus told him. "The fat fellow said that the car would run fine for about two miles, then stall, and then start again after about 15 minutes. That meant, in all probability, that expansion of some part after the engine got warmed up was cutting off the gas. The gasoline line and the fuel pump were O. K. The most likely trouble maker was the fuel strainer. When I looked at it I remembered a trouble-shooting job I had a few years ago—one in which the fuel strainer was of the same type as this one, and in which the engine had acted the same way. In that model fuel strainer the gas has to pass through some thin metal disks to get into the carburetor, and on the job I remembered the grief had been caused by those disks expanding when the engine got hot. Apparently there wasn't anything wrong with the strainer on Holcomb's car, so I knew what the trouble must be—and that the car would stall again after it had gone about two miles."

"Some detective!" Jim said admiringly. "One of J. Edgar Hoover's G-men could be proud of a job like that!"

"Nope," Gus disclaimed modestly. "Just a matter of memory."

CHAMPION SPARK PLUGS

The Civil Air Patrol is a typically ingenious American organization comprised of 55,000 men and women fliers, voluntarily united into a semi-military organization co-operating with our military air forces. Authorized to patrol shipping lanes on all coasts, the C.A.P. has established itself as one of the most useful and dependable branches of the O.C.D. Champions are prime favorites with these pilots because they know they are absolutely dependable in their planes as in their cars.



It's squarely up to you to make your car last for the duration. S-L-O-W down your driving habits to conserve your tires.—S-T-R-E-T-C-H the mileage you get from every gallon of gas, to the maximum. Check your spark plugs regularly. Have a Champion Spark Plug Dealer test and clean them every 4,000 miles. These economical practices are your patriotic duty.

"Old plugs invite trouble", and winter is just around the corner! Cold weather causes hard starting and increased use of choke resulting in wasteful gas consumption. If your spark plugs are worn out or of inferior quality, economy and efficiency are further handicapped. In this event, new Champions are sound economy.

TO SAVE GASOLINE • KEEP YOUR SPARK PLUGS CLEAN

100,000,000-Volt Giant

(Continued from page 63)

300,000-volt tube especially designed to make X-ray pictures of the drums for the mercury turbine developed about 1932.

During the past few years, as a result of the development of new methods and devices by Dr. Charlton and others backed by the engineering staff of the General Electric X-ray Corporation, the tempo of achievement has increased. Dr. Coolidge had in an earlier period discovered the principle of "multistaging" for very high-voltage tubes. That is, the voltage was applied in successive controlled steps to speed up the electron beam, but tubes were limited in the number of stages. This was because of the difficulty of focusing the beam on a target as the length of the beam path increased. Dr. Charlton found that the beam was affected by external fields as weak as the vertical component of the earth's magnetic field but could easily be controlled by placing a small U-shaped magnet near the cathode, the source of the electron beam. This magnet compensated for the magnetic field of the earth and sent the electrons forward in a straight line. This discovery made successful the first of the four-stage tubes. Such tubes, designed for 800,000 volts, were incorporated in X-ray units installed in hospitals in Chicago and Seattle with the cooperation of the G.E. X-ray Corporation.

Research on improved gaseous insulating mediums, combined with an exceedingly novel design of a new high-voltage transformer by Westendorp, led to a marked reduction in the size of the entire generating unit for producing million-volt X-rays.

Freon gas, developed by the Kinetic Chemicals Company for use in electric refrigerators, was found to have valuable electrical properties giving several times the insulating strength of air for high-voltage systems. Its use made possible great reduction in the size and weight of a million-volt X-ray unit.

The resonance transformer, as Westendorp's high-voltage transformer is called, eliminates the iron core ordinarily placed in the center of the coil. It permitted a tremendous reduction in the size of the unit.

By combining the features of the multistage tube, the Freon gas insulation, and the resonance transformer, the new type of million-volt X-ray machine was developed. It was a great reduction in size and weight over its predecessors. Units of this type, with 12-stage tubes, were installed in various hospitals in New York, Cleveland, and Buffalo.—HERBERT ASBURY.

HEY! WHAT'S HE GOT THAT WE HAVEN'T?
W. L. Douglas Shoes
In buying shoes today, the reputation and integrity of the manufacturer should be your first consideration. Douglas gives you long-wearing comfort, good looks, and styles in step with the walking and working needs of a nation at War. Where you see the familiar W. L. Douglas sign — you'll find friendly, helpful service.
Douglas "Down-to-the-Wood" construction assures better fit and greater comfort.
The DARTMOUTH
Rugged lines well suit the fine, flexible leather of this moccasin type blucher oxford. A typical Douglas Value. Style 4554.
94% of our 1100 employees are buying war bonds.
DOUGLAS ARCH
Douglas Arch style in black calf. Perfect fitting last and specially constructed innersole gives added comfort. Style 4019
W. L. DOUGLAS SHOE CO.
BROCKTON, MASS.
Other Stores in Principal Cities
Good Dealers Everywhere
SINCE 1876—AMERICA'S BEST-KNOWN SHOES
$5.50 $6.50
CUSTOM AND NORMAL TREDS $8.50

Light Control

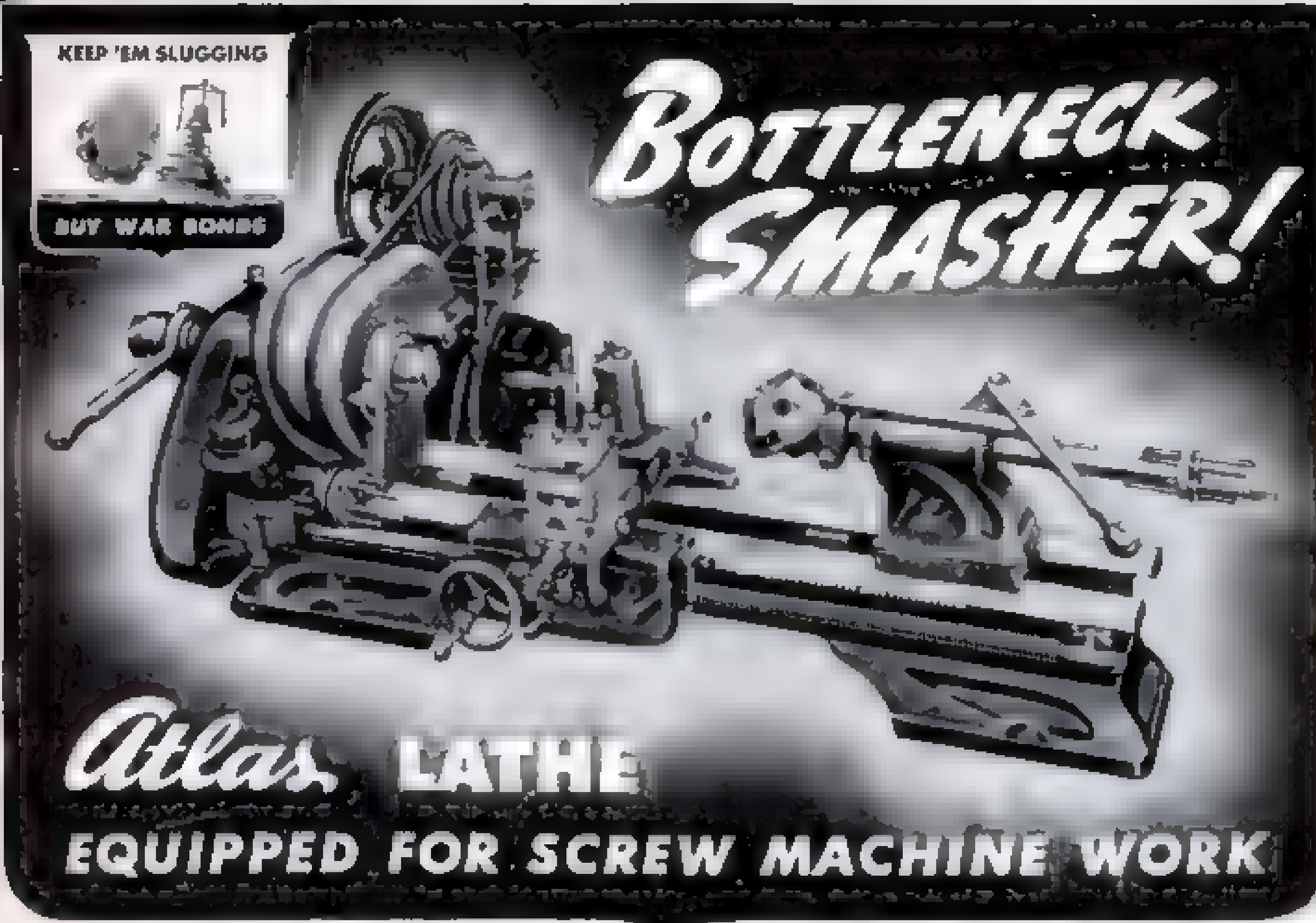
(Continued from page 120)

three discoveries which will not only prove to be milestones in the history of optical science, but be of great immediate benefit to America's war effort. One is a so-called rare-element glass made without sand by the Eastman Kodak Company. Another is a nonreflecting glass developed by Dr. Nicoll of the Radio Corporation of America. The third is a new annealing process devised by Dr. E. D. Tillyer, research director of the American Optical Company, which greatly increases the percentage of glass recoverable from the pots, and makes possible mass production of fine instrument lenses.

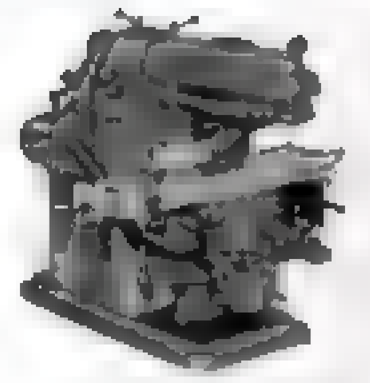
With the old methods of annealing, uniformity of structure, or freedom from internal strains, is obtained by a process of "fine annealing," in which the pieces of optical glass are placed in rectangular molds and heated in furnaces until they assume the shape of the mold. This process required about 30 days, and has always limited productive capacity. In studying the rate of contraction and expansion in samples of optical glass, Dr. Tillyer found at one point in the curve a hump which indicated difficulty in atom adjustment and thereby affected uniformity. Putting the glass in an accurately controlled electric furnace, he increased the temperature at this point, held it there for a time, and then allowed the glass to cool. The result was a glass of almost absolute uniformity, and with a higher index of refraction than had ever been obtained by any other process of annealing—in other words, the glass for which optical scientists have been searching for years, and which will make American instrument lenses the finest in the world. Light will follow a straight path through a lens annealed by the Tillyer process, and hence will be subject to a greater degree of control than ever before.

The rare-element glass, which was eight years in development, has been described by the Eastman Kodak Company as the first basic optical-glass discovery in over half a century, "almost as revolutionary as if someone had discovered how to make steel without iron." The new glass is said to possess an extremely high index of refraction, making possible a lens of much less curvature for a given focal length. It is being manufactured in small quantities for use in aerial photography, and pictures taken with it cover larger areas with larger aperture ratios, and give better definition

(Continued on page 224)



American industry has scored again! Pictured above is the set-up that has helped many a war plant out of a bad hole in small part production. It just hasn't been possible to build enough screw machines so resourceful production engineers have turned to the modern Atlas F-Series 10" Lathe equipped with tailstock turret and lever-type collet chuck. Operation is quickly mastered by beginning workers. Serious production bottlenecks are being smashed right and left!


MILLING MACHINE


SHAPER

"Match the machine to the job" is the Atlas idea for war manufacturers — big machines for big work, modern compact machines for small precision work so that capacities of larger machines will not be wasted. It's a production idea that is getting real results as more and more Atlas Lathes, Milling Machines, Shapers, and Drill Presses go into key plants throughout the nation. Atlas Press Company, 1255 Pitcher St., Kalamazoo, Michigan.


DRILL PRESSES

VICTORY FIRST! - THEN Atlas TOOLS FOR YOU

Light Control

(*Continued from page 222*)

than with other lenses. It cannot be used generally for photographic and other instrument lenses until new grinding formulas have been worked out, a long and laborious procedure.

Dr. Nicoll's nonreflecting glass, which is based upon the phenomenon of interference, is an improvement upon the so-called "invisible glass" developed a few years ago by Dr. Katherine Blodgett of the General Electric Company. Dr. Blodgett succeeded in causing complete interference between two beams of light by coating a sheet of glass with a film four millionths of an inch thick. But the film was impermanent, and little was done with Dr. Blodgett's discovery outside of the laboratory. Dr. Nicoll's method is to expose the glass to hydrofluoric acid vapor, which etches the surface and leaves a film of calcium fluoride about one fourth as thick as the length of a light wave.

When a batch of optical or ophthalmic glass finally comes from the annealing pots or ovens, samples are given severe laboratory tests which vary according to the purpose for which the glass is intended. If the tests are satisfactory, the chunks and sheets are sent to the lens factory to be made into lens blanks for spectacles, or lenses and prisms for the innumerable types of optical instruments, of which Bausch & Lomb alone manufacture more than a thousand. In the instrument field virtually all of the important developments of the last few years have been incorporated into apparatus used by the Army and Navy, or in war production, and are military secrets. In the control of light for purely visual purposes, probably the greatest recent advance is represented by the iseikonic lens developed after years of research by the American Optical Company and the Dartmouth Eye Institute. These lenses are intended to correct an eye defect called aniseikonia, which through inequality of the two ocular images may give rise to incorrect spatial localization. In extreme cases one eye may eventually give up the struggle. Once thought to be rare, aniseikonia is now known to be fairly common. The task of designing the iseikonic lenses is extremely complex, and the original chart used in the lens design was about a mile long. Later it was reduced to 50 yards, and has since been simplified and consolidated until it now covers a single sheet of graphs. More than 6,000 persons have already had the defect corrected by means of glasses fitted with iseikonic lenses.

HELLO BOYS! Here's Fun and Action!

BOYS! Look and listen for the most thrilling and realistic sounding American Flyer "Hot Shots" that ever pounded down the track.

See 'em in action . . . hear 'em choo-choo! American Flyer's exclusive built-in choo choo actually reproduces the lusty tingling sound effect of a real train. You can hear those choo chugs 100 feet away. And they are so realistic they change tone and tempo with every change in train speed. The greatest extra fun feature ever added to electric trains.

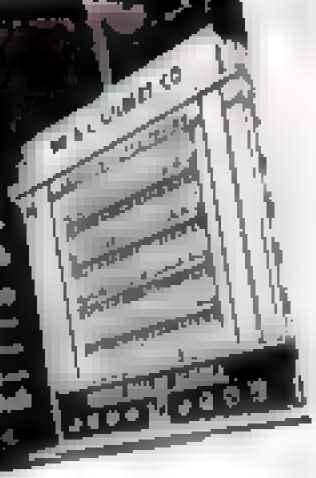
Here's more exciting news. Every locomotive and car built to 3/16" scale from railroad blueprints. Every locomotive has super power worm drive . . . *Automatic Coupling and Electric Uncoupling . . . Semaphore and Block Signal Systems*—built to scale—automatically stop and start your train . . . *Remote Control Whistling* direct from train . . . *8 Drive Wheel Locomotives* . . . See and hear the new American Flyer at your local dealers.

GILBERT AMERICAN FLYER TRAINS

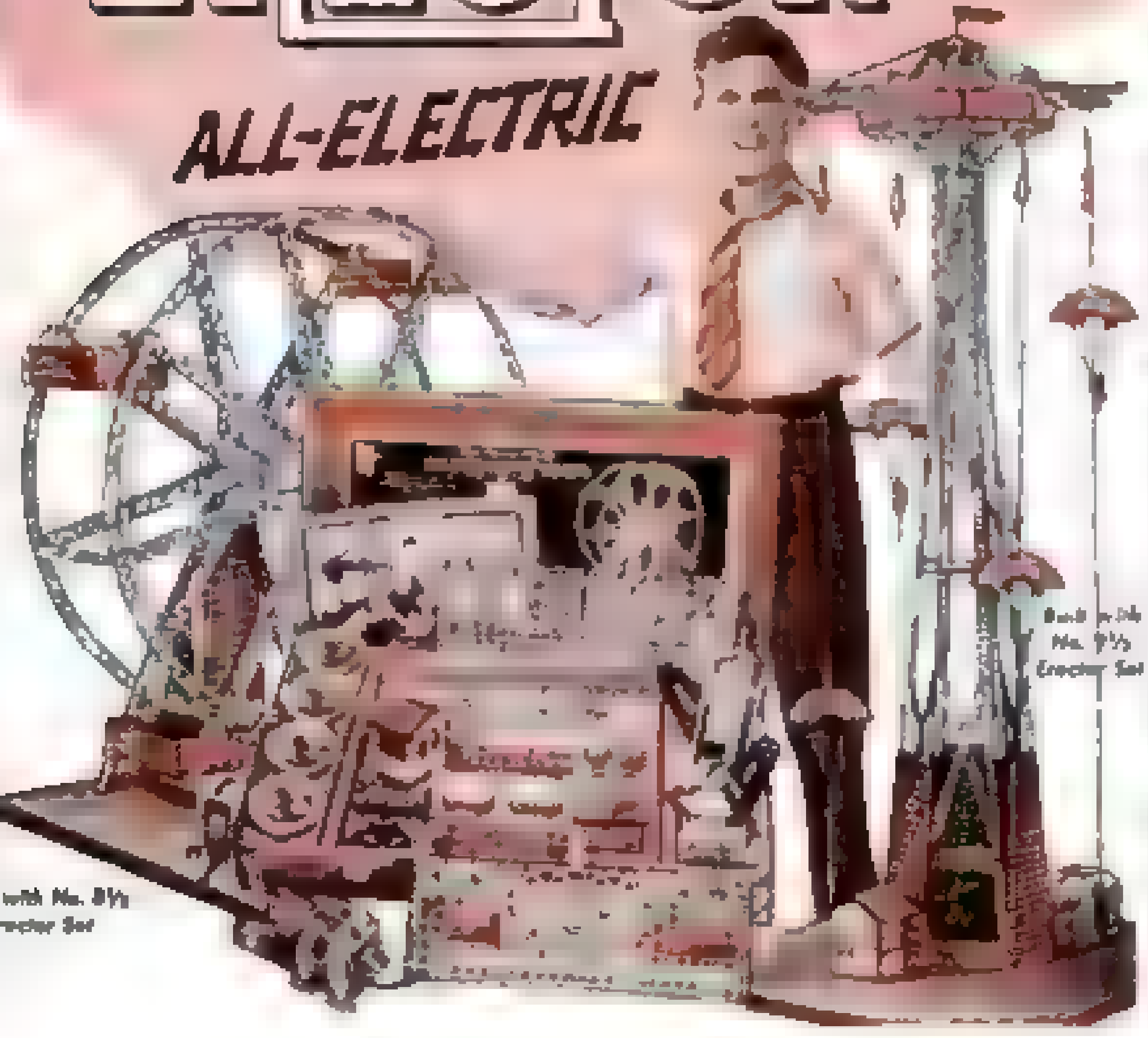
HEAR 'EM "CHOO-CHOO"

Toys on sale were manufactured many months ago and Gilbert production facilities are now devoted to war materials. If you can't get the set you want, just be a good sport and a good American about it.

Visit the GILBERT HALL OF SCIENCE



SUPER-MECHANIZED ERECTOR ALL-ELECTRIC



Built with No. 8½ Erector Set

Built with No. 8½ Erector Set

It's colossal, boys . . . that towering Erector army training parachute jump. Piece by piece you build it yourself. Click a switch and the powerful Erector electric engine hoists the four parachutes up and up. Then watch them plummet downward—unfold—and float to the ground.

Now get a load of that mighty Ferris wheel. It whistles—twinkles with light—operates in either direction at slow or high speed.

You can build *hundreds* of spectacular mechanical marvels with *one* Erector set. The Erector electric engine makes them buzz with action! See my new Erectors at your nearest toy store. *A. C. Gilbert, President.*

BOYS! Send 10¢ for big 48-page illustrated American Flyer Train catalog. Or mail post card for free 24-page book "Fun and Action for Boy Engineers." The A. C. Gilbert Co. 106 Erector Square, New Haven, Conn. Offer good only in U. S. A.

It's the Thunderbolt

(Continued from page 113)

thing to resemble the current Thunderbolt was the XP-47B itself, the first hand-built experimental pilot model which emerged for test flight in May 1941.

Lowry L. Brabham, at present Republic's chief of operations, did the original test flights. While no prototype is anywhere near totally satisfactory, Brabham's negative criticism was summed up in a couple of terse paragraphs. There were less than a half dozen minor alterations before the XP-47 was accepted by the Army in August 1941 as an official type. Then began the painful process of retooling the plant without undue slowing of production. That was only a year ago and there was not, as yet, the stimulus of an actual war.

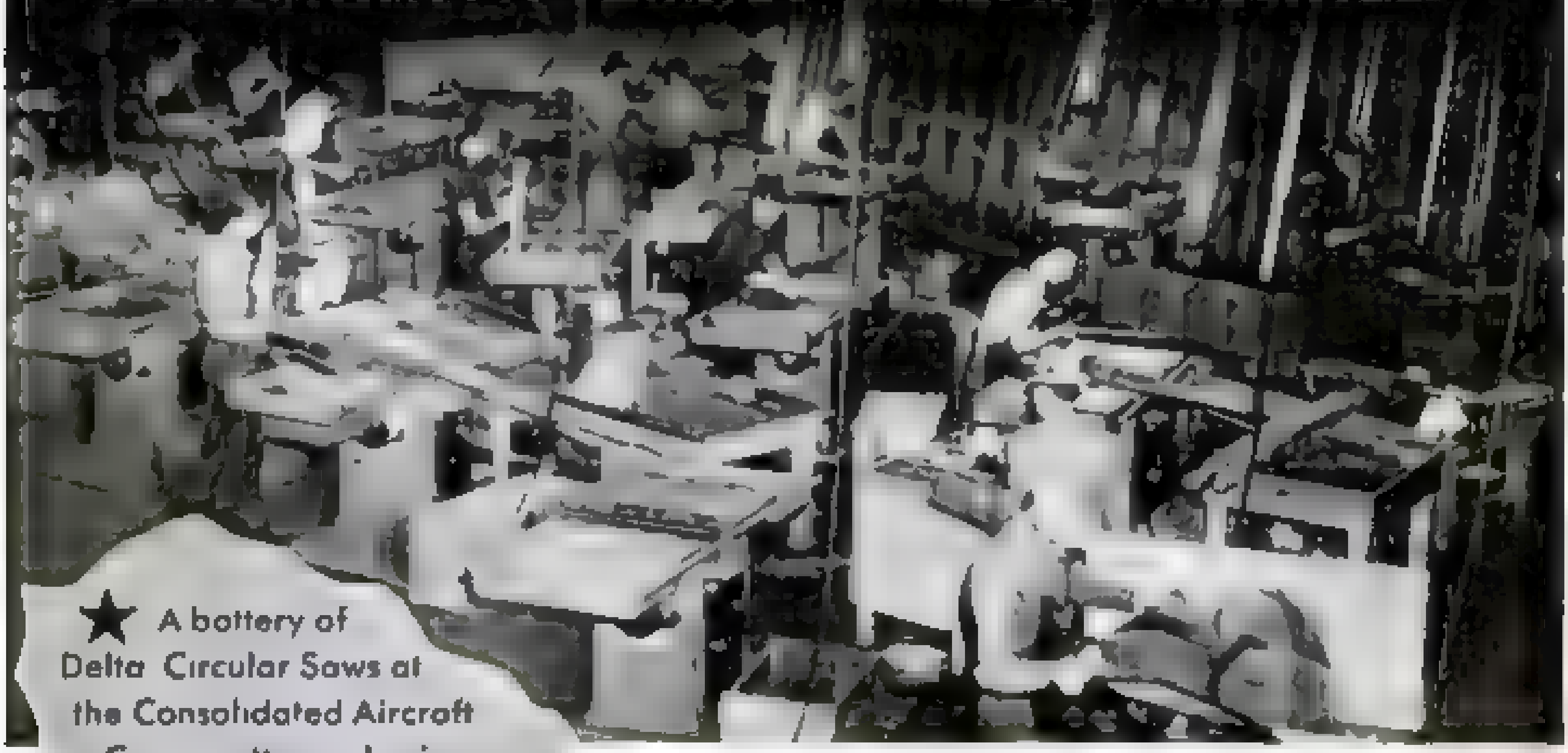
By many accepted standards, or, more correctly, by preconceived notions, the P-47 should be a comfortable, easy-flying, mid-speed military ark. Its big, deep-bellied, heavy setup give the external impression of being designed for adequate room inside. Generally, its round, well-fed, almost bulbous figure is almost the direct antithesis of the Hawker Hurricane and Supermarine Spitfire with their knifelike lines, spare wings, frail-looking landing gear: every inch trimmed to offer as little frontal area as the tiny-faced V-type liquid-cooled Rolls-Royce engines allowed.

To begin with, the Thunderbolt is no hollow shell. From propeller hub to rudder light, from red to green wingtip position light, virtually every cubic foot of this craft contains some device with a direct bearing on flying, communication, or homicide. Exactly what's inside is, for the time being, restricted military information. Let it suffice that when one has to stagger eight heavy-caliber guns into a wing; swing in two seven-foot landing legs with tires, brakes, and retracting gear; leave room for a self-sealing tank and still enough remaining space for ailerons, flaps, and their controls, there isn't much space wasted inside.

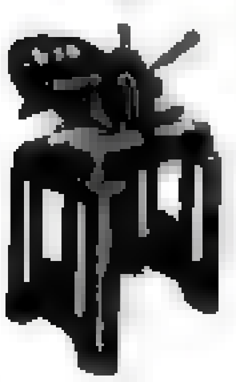
There's a lot of power plant in front of the cockpit, and squeezing over a horsepower a pound out of those 18 cylinders under any altitude or condition takes a lot of plumbing and wiring. Handling an airplane that big on a cross-country flight would be a job by itself. Fighting it is tougher still. To ease the proposition, as much automatic control as possible is incorporated. Instruments, radio, and the complicated oil-cooling system occupy a lot of the forward space in the fuselage.

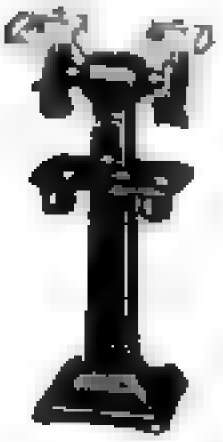
(Continued on page 228)

When the Crisis Came...
DELTA MACHINES WERE READY!



★ A battery of Delta Circular Saws at the Consolidated Aircraft Corp., cutting aluminum alloy sheets.





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In the meantime, keep in touch with latest developments in the crafts field by subscribing to the Deltagram. This unique craftsman's magazine is published 6 times a year—during the months that every home workshop owner can best use it. It is crowded with exclusive new and different plans and ideas—plus hundreds of helpful, practical shop suggestions. Mail the coupon today!

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It's The Thunderbolt

(Continued from page 226)

The exact location of the supercharger is also restricted. However, it, and the cooling, intake and exhaust system occupy over half of the fuselage capacity. Add to this oxygen and stratosphere-range communication equipment and an electric generating system, and one realizes that it took clever internal architecture to give the pilot one of the most generously sized and best-appointed cockpits in the fighter class.

For high-speed aircraft, most people have learned to think in terms of liquid-cooled V-type power plants, because small frontal resistance has been considered a prime factor in stepping up speed. This theory holds true up to about 350 m.p.h. Past this point, it is indicated that the skin friction (air resistance to parallel surfaces) begins to square as speed mounts. The drag of the long cowling on the liquid-cooled in-line power plant begins to approach that of the frontal resistance of the short-cowled radial. There is a point, somewhere above 350 m.p.h., where the same airframe powered by either an in-line or a radial of the same power would have the identical speed. When this point is approached, it is obvious that, particularly in military aircraft, the air-cooled power plant has certain advantages.

So far, the Axis has produced only one close parallel to the P-47, the Focke-Wulf 190. It can be said quite honestly that they are different approaches to the same problem. Investigation shows that they were begun about the same time. Living nearer to the scene of pressure, the 190 is a little ahead in production. The only specific similarity is in the highly supercharged power plants. As a matter of fact, the FW-190's 1,700 to 2,000 h.p. engine is a remote cousin to the Pratt & Whitney in the Thunderbolt, having descended from old single-row Pratt & Whitney Hornet engines which were built by the Bayische Machin Werke under American license many years ago.

Another accepted idea that the Thunderbolt shatters is one about relative weight. For good climb and performance in the thin air above 20,000 feet, the lightest wing loading (total weight divided by wing area) was usually advised. The much-discussed Mitsubishi Zero, by scrapping structural strength and armor, pared wing loading to less than 20 pounds per square foot. The Spitfire loads to 27 pounds, the Hurricane to 28. The Thunderbolt loads heavier than any of these, yet its high-altitude performance is phenomenal. How does it get that way? Wouldn't Goering like to know!

Tank-Killing Guns

(Continued from page 133)

would have four times the penetration of a one-pound projectile with a striking velocity of 2,000 feet a second, and twice the penetration of a two-pound projectile with a striking velocity of 2,000 feet a second.

It takes a lot of time to design an entirely new gun, test it out, and get it into production, and in many cases designers have been able to save that scarce wartime commodity by developing medium-velocity guns into high-velocity weapons while retaining parts of the original mechanism. Detailed information about such hurry-up conversions is not available, but the methods used are essentially the same as the method outlined for increasing the velocity and penetration of the entirely supposititious 2½-inch gun shown in the drawing on page 130.

This method was followed in 1939 in developing our World War 37-millimeter one-pounder, loved by every doughboy who ever saw it plugging its little shells into a pillbox or machine-gun nest, into our highly-efficient 37-millimeter antitank gun. Originally its muzzle velocity was 1,276 feet a second. By increasing its powder charge and lengthening its barrel, its velocity was increased to 2,600 feet a second, giving it an armor penetration of 1¼ inches at 1,000 yards. Since then another increase has been made.

A somewhat similar job has been done on our 75-millimeter field gun in developing it into a tank gun which outranges the Nazi tank gun of the same caliber.

In addition to the high-velocity guns developed by our Ordnance Department, the Army has adopted several foreign guns of this class, which now are in quantity production here. One of them is the Bofors funnel-mouthed 40-mm. (1 6/10-inch) automatic field gun which has a muzzle velocity of 2,850 feet a second, a vertical range of 9,600 yards and a horizontal range of 11,000 yards, and a practically straight trajectory up to 3,280 yards.

Army interest in hyper-velocity guns dates back to 1933, when extensive tests were made at the Aberdeen Proving Grounds of the Halger-Ultra military rifle, a weapon of terrific velocity, remarkable armor-piercing capabilities, and revolutionary design.

The Halger-Ultra was the invention of H. Gerlich, a St. Louis-born German small-arms enthusiast who had served an apprenticeship in big-gun making in the British plant of Vickers Sons and Maxim.

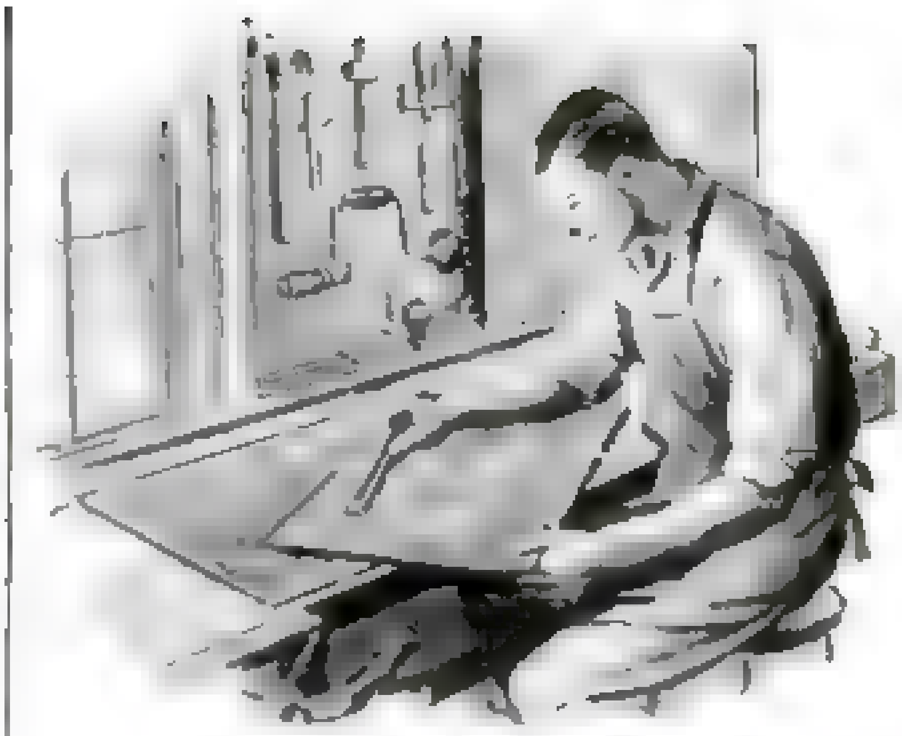
Gerlich's rifle had a muzzle velocity of over 5,000 feet a second, which made the

2,700 feet of most military rifles seem slow, and outclassed even the 4,140 feet of the little .220 Swift, the fastest-stepping commercial cartridge. The revolutionary feature of the Halger was that the bullet which went into the firing chamber a .35 caliber came out of the muzzle a .28 caliber projectile. The body of the bullet, which had a soft iron jacket and a soft lead core, was .28 caliber. Soft lead wings, shown in the accompanying sketch, brought its size up to .35, the caliber of the cartridge case. When the rifle was fired the gas pressure released by a charge of slow-burning nitrocellulose powder acted against the comparatively large base of the light bullet, and started it through the barrel at tremendous speed. It traveled for a few inches through a .35 caliber cylinder, then entered a cone which reduced the bore to .28 caliber In its passage through this reducing cone the soft lead "wings" were pressed back onto the body of the bullet.

Gerlich's rifle wasn't adopted by our Army because its practical advantages as an infantry weapon weren't sufficient to balance the high manufacturing cost of a rifle with three different bores in its barrel.

The inventor died in 1935—but the Nazis didn't let his idea die. In the fighting in the Libyan desert the British were badly bothered by small-caliber German antitank guns which had remarkable armor penetrating ability. Finally they captured one of these pestiferous weapons, and some of its ammunition. Prisoners said it was called a Gerlich gun. Tests showed that its muzzle velocity was 4,750 feet a second—that it was the highest-velocity gun they ever had gone up against. Like Gerlich's Halger-Ultra rifle, it has a reduction cone, which caused the Tommies to call it a "squeeze gun." Its solid-steel armor-piercing projectile is of 20-millimeter diameter, but it has a soft metal tail and fins which bring it up to 28 millimeters, the diameter of its cartridge case. The gun works in practically the same way that the Gerlich rifle worked: when the projectile passes through a reducing cone its soft metal fins are folded down on the steel core and the soft-metal tail is pressed back into a streamlined shape.

Some British antitank officers say that it is the best antitank weapon developed so far, and that it should be developed into the top antitank gun of the near future. Others say that its ultra-high velocity can be equaled by a gun of more conventional design. They all say—and American antitank officers agree—that guns of very high velocity and very flat trajectory, perhaps equipped with some form of lead-computing sight, are what is needed to kill tanks.



Extra Cash for Shop Owners from Craftwork Gifts

NOW is the time to earn extra dollars in your home shop. Keep it humming by making Christmas gifts. War needs have sharply reduced stocks of manufactured articles, and there is a real demand for gifts made of wood and other noncritical materials. You can make presents for those on your own Christmas list and sell gifts to others.

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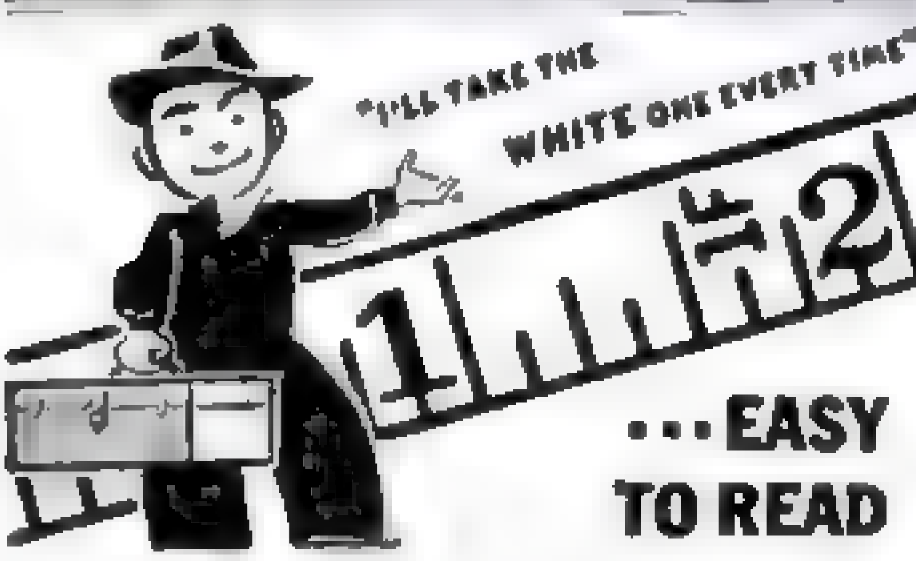

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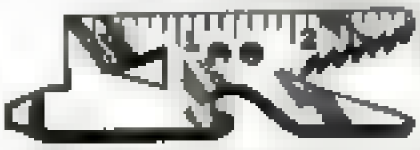

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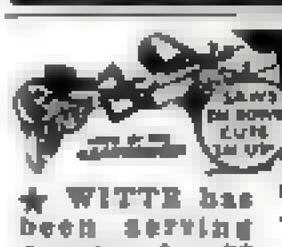

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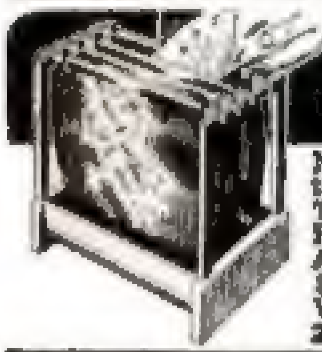
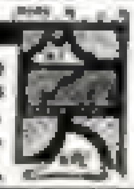
(Signed) Godfrey Hammond, Business Manager.

Sworn to and subscribed before me this 25th day of September, 1942. Esther Erl, Notary Public, Kings County. Kings Co. Clerk's No. 72, Registry No. 4052. New York County Clerk's No. 194, Registry No. 4 E 103. (Seal) My Commission expires March 30, 1944.





HOW TO GET THE MOST OUT OF YOUR LATHES

No. 2 in a series of suggestions made by the South Bend Lathe Works in the interest of more efficient war production.

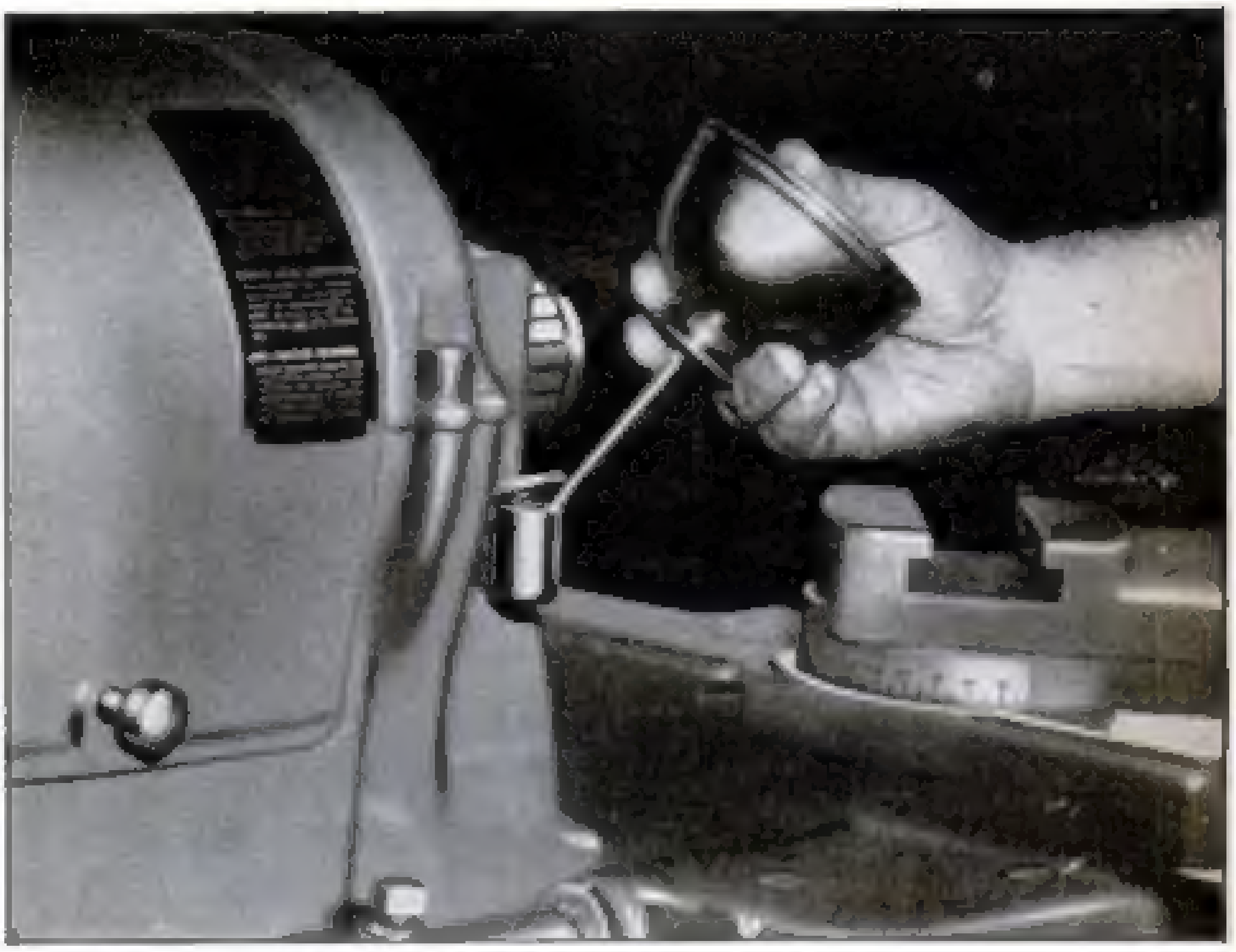
Keep Them Well Oiled

For lack of oil the bearing was lost;
For lack of a bearing the tank was lost;
For lack of a tank the battle was lost;
All for the lack of a film of oil.

Cleverly paraphrasing the ancient rhyme about the horseshoe nail, a young army officer is said to have used the above verse to emphasize the importance of lubrication in mechanized warfare. And this thought is just as applicable to the battle of production in American shops as it is to the tank battles in distant lands.

The proper lubrication of lathes and other machine tools will contribute much to our total war effort by preventing unnecessary interruption of production. It will also save scarce strategic materials and highly skilled technical labor by reducing to a minimum the demand for replacement bearings, parts, and machines.

South Bend Lathes, like other fine machine tools, have large oil reservoirs, felt wicks, and oil retainers to guard against lack of oil due to temporary neglect or oversight. But for best results the lathe should be oiled at regular intervals. Even a camel must have an occasional drink.



All bearings should be oiled at regular intervals

Make Oiling a Habit

All oil holes and oil cups on the lathe should be filled at least once a day — oftener when the lathe operates day and night — or when top speeds and feeds are employed. The best method is to fill each oil hole in a regular sequence so that oiling becomes a habit and no oil holes are overlooked. When the lathe is in service on two or more shifts, oiling the lathe should be the first daily task of each operator.

To help the inexperienced operator find the oil holes, a circle of brightly colored paint may be applied around each oil cup. Different colors of paint can be used to indicate different grades of oil.

Use Correct Grade of Oil

When the correct grade of oil is used in a well designed bearing there is little or no metal to metal contact and practically no wear. However, when the wrong grade of oil is used, or if the oiling is neglected, the oil film will break down and the fine finish of the bearing surface may be damaged in a short time.

The V-ways of the lathe bed, and the dovetails should be oiled as often as is necessary to maintain a good oil film. Touching the bed way with the tip of the finger will indicate whether or not it is coated with a film of oil.

Motors should be lubricated according to the motor manufacturer's instructions which are usually attached to the motor. Care should be taken to avoid getting oil on rubber V-belts or flat leather belts, as it is injurious to both.

Clean Lathe After Oiling

After the oiling has been completed, the excess of oil should be wiped off with a clean cloth. The lathe should be kept clean. Dirt, chips, or rust should not be allowed to collect.

Write for Bulletin No. H2

Bulletin No. H2 giving more complete information on oiling the lathe will be supplied on request. Oiling charts for South Bend Lathes, and reprints of this and other advertisements in this series can also be supplied. State quantity wanted, also serial numbers of lathes for which oiling charts are needed.

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